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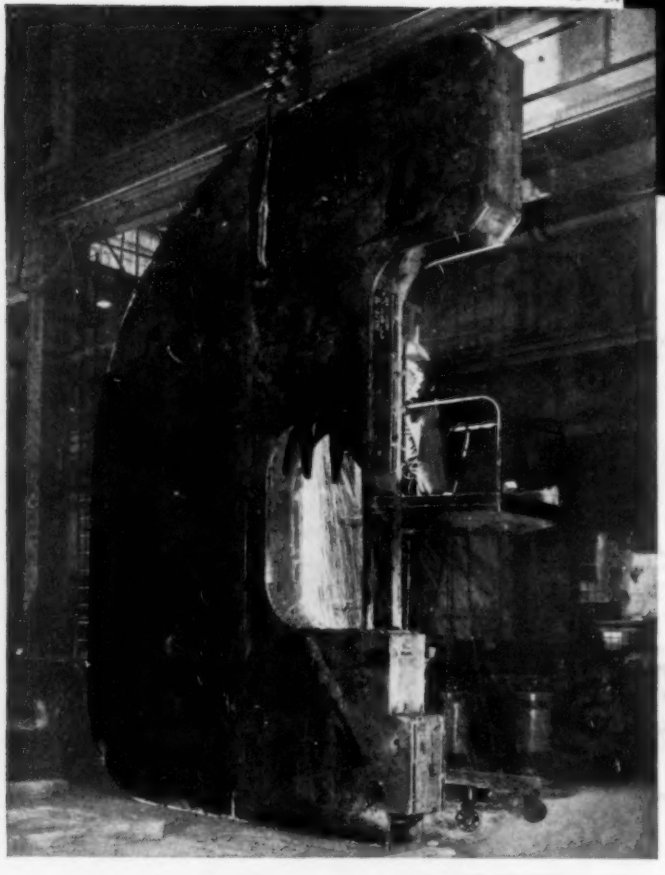

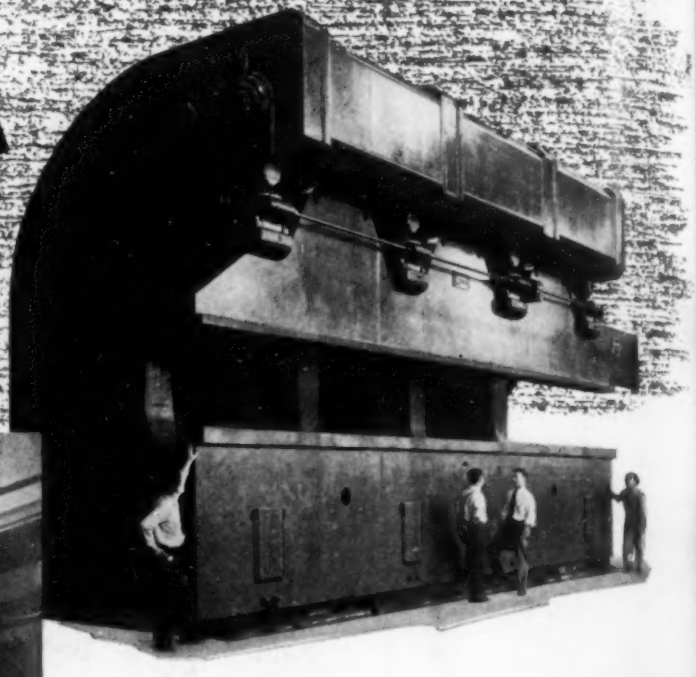

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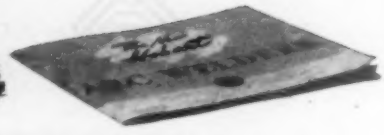

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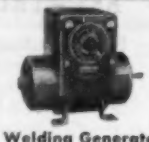
4. 

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COVER

Welding Side Section River Barge in the Dravo Structural Shop.

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Subscriptions $5.00 per year in United States and possessions; Foreign Countries $7.00. Single copies, non-members $.75; Special issue October $1.00; members 50 cents.

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.
EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York 18, N. Y.

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The Journal of
The American Welding Society
VOLUME 27 · NUMBER 1 · JANUARY 1948

Shape-Welding by the Submerged-Melt Welding Process*

By J. A. Kratz†

THE purpose of this paper is to present and discuss the methods used in mechanized shape welding—that is, the joining of the pieces of an assembly, in which the direction of the weld changes as the welding action proceeds.

There are a number of special conditions which must be taken into account when considering shape welding with the submerged-melt welding process. The welding zone must be maintained in a horizontal plane because of the large pool of molten metal which is a characteristic of this process. In addition, the welding rod must be maintained in the plane of the center line of the weld, and it must travel at uniform linear speed with respect to the work surface regardless of the shape of the work piece. Since the process is automatic, the manipulating equipment must be also designed and coordinated to automatically meet these conditions.

There are, in general, three kinds of continuous machine welds; straight-line, circular and irregular. Straight-line and circular welding are the most widely used applications of machine welding. Various examples of these methods are shown in the accompanying illustrations. Straight-line welding is performed by moving the welding head along the line of work or moving the work past a stationary welding head. The welding of the longitudinal seam of a tank is an example of straight-line welding in which a mechanized carriage transports the welding head at the proper speed over the work. This is shown in Fig. 1.

* Presented at Twenty-Eighth Annual Meeting, A.W.S., Chicago, Ill., week of Oct. 19, 1947.
† Engineer, Unionmelt Division, The Linde Air Products Co.

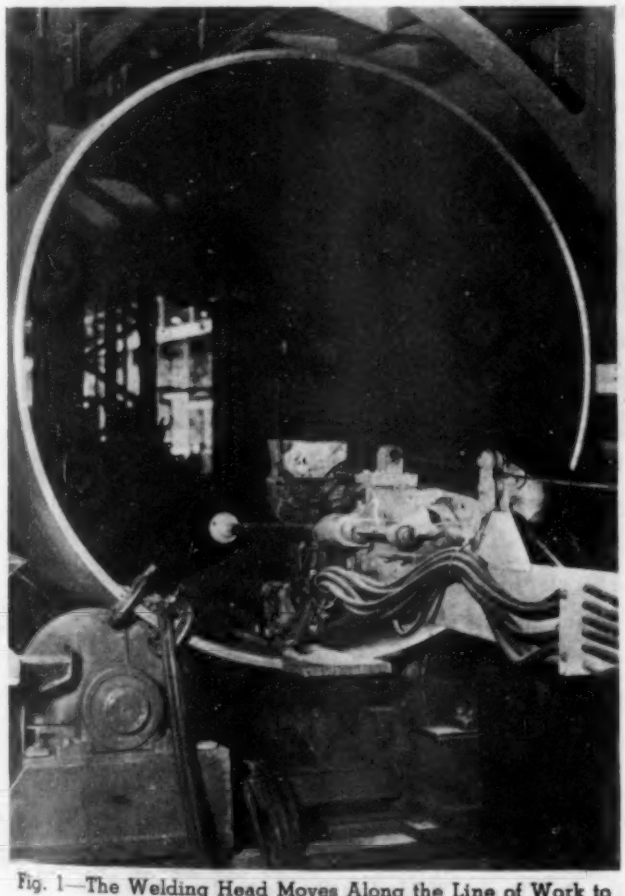

Fig. 1—The Welding Head Moves Along the Line of Work to Weld the Longitudinal Seam

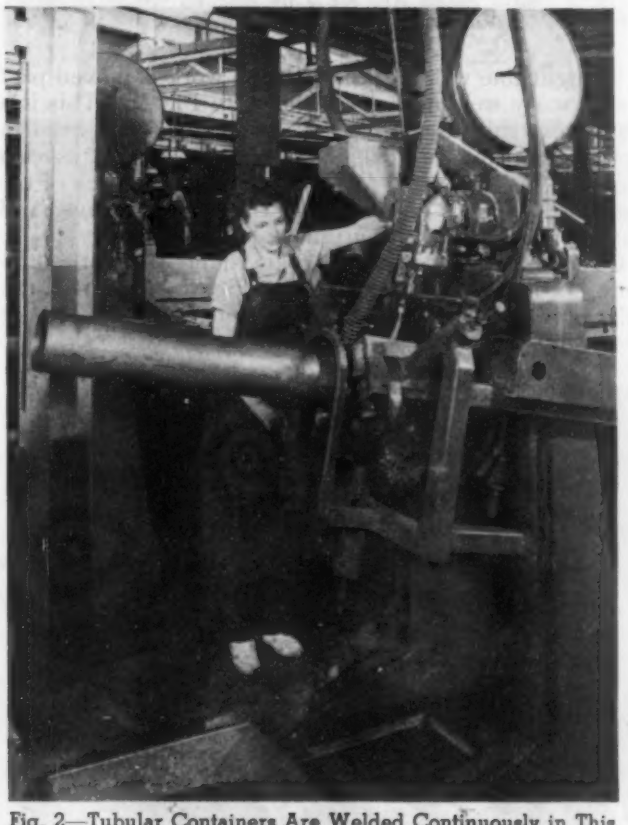

Fig. 2—Tubular Containers Are Welded Continuously in This Continuous-Type Mill

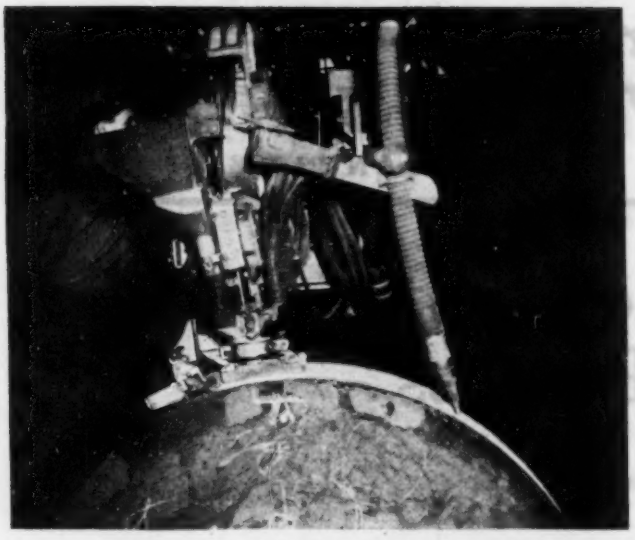

Fig. 3—Girth Seams Are Made by Rotating the Workpiece Under a Stationary Welding Head

Straight-line welding in which the work is moved past a stationary welding head is shown in Fig. 2. This is a continuous mill used with a stationary welding head in welding the longitudinal seams of tubes. (Flat sheets are rolled to cylindrical form and fed into the back of the machine. Each section follows the preceding one, and the welding process is continuous.)

Circular girth welds are made by rolling the section under a stationary head as shown in Fig. 3. In this particular operation the dished head is being welded to a large size pressure vessel.

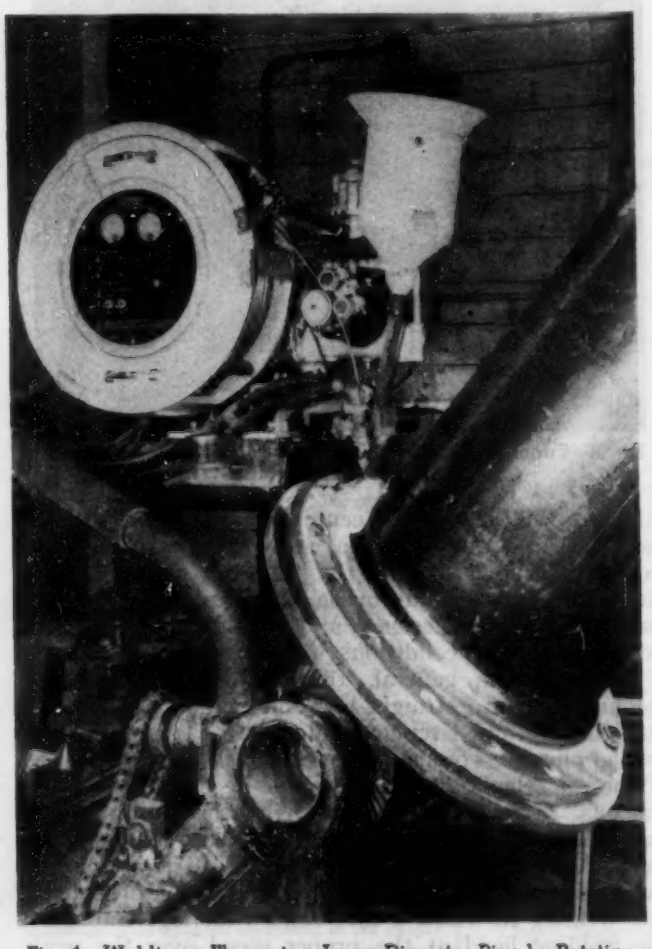

Fig. 4—Welding a Flange to a Large Diameter Pipe by Rotating the Workpiece on a Positioner

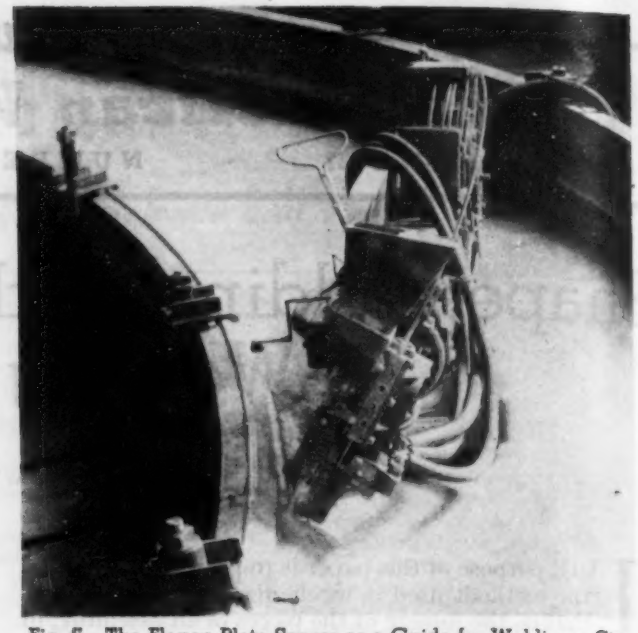

Fig. 5—The Flange Plate Serves as a Guide for Welding a Circular Girder

Circular fillet welds are made by rotating the assembly on a positioning mechanism under a stationary welding head. An example of this method is shown in Fig. 4 where a flange is being welded to large-sized pipe.

In straight-line, and most circular welding, the welding head is stationary or it moves in a single straight line. In shape-welding, the head must move in two or sometimes three dimensions. Shape-welding includes the making of circular welds in the flat plane where it is not desirable or possible to rotate the weldment, irregular shapes in the flat plane and circular or irregular shapes on curved surfaces.

Fig. 6—A Radius Rod Guides the Welding Machine in a Circle to Weld the Hub of This Wind-Tunnel Fan Assembly

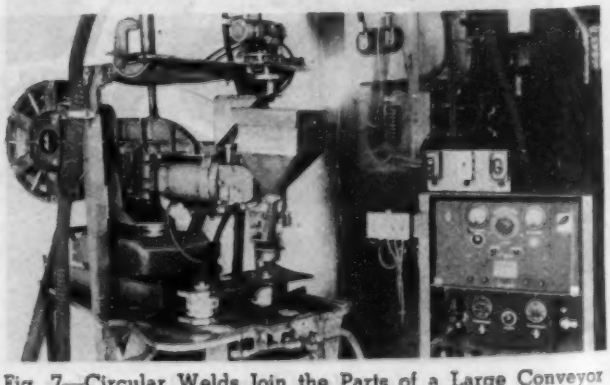

Fig. 7—Circular Welds Join the Parts of a Large Conveyor Chain Link

The method used to make circular welds in the horizontal plane will depend on the size of the weldment. In the welding of large circular pieces, the carriage can be guided by the workpiece itself. An example of this method is the welding of a circular girder shown in Fig. 5. The regular carriage guide wheel was toed in, tending to force the carriage against the flange. An additional guide wheel fastened to the carriage rolled on the inner flange and kept the carriage a specified distance from it. The same method was used for welding the outer flange.

When the circular welds are somewhat smaller in diameter, the method shown in Fig. 6 may be used. A radius rod or bar fastened to the carriage and pivoted at the center of the workpiece determines the radius of the circle the carriage will describe. The illustration shows how this method is used to join the web to the flange and hub of a wind-tunnel fan-center assembly.

For very small pieces the welds can be made by using a motor-driven eccentric pin to swing the welding head in a circle. An example of this method, shown in Fig. 7, is the fabrication of large-size link chains. The welding head supporting hinge was unlocked so that the head could swing free, and the carriage drive was put in neutral so that the eccentric pin could drive and guide the welding head in a circle. The bushing of the chain were welded to the side pieces of each link by 3-in. diameter circular welds. Figure 8 shows the various parts used to make the links and a completed link, showing the circular welds.

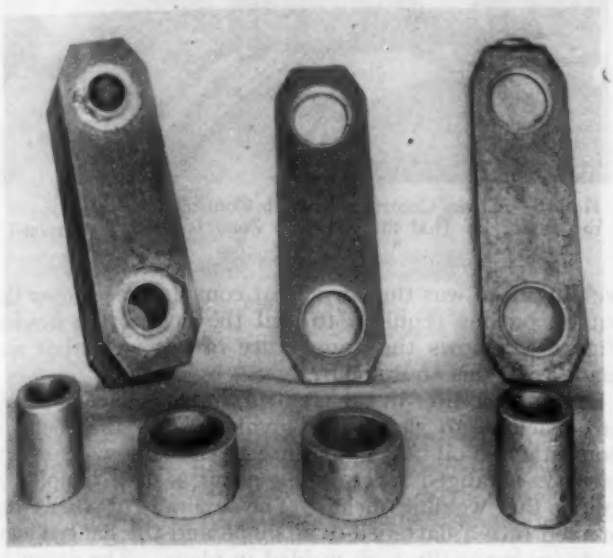

Fig. 8—The Completed Link and the Parts That Comprise It

Fig. 9—A Templet Guides the Welding Head to Any Desired Contour

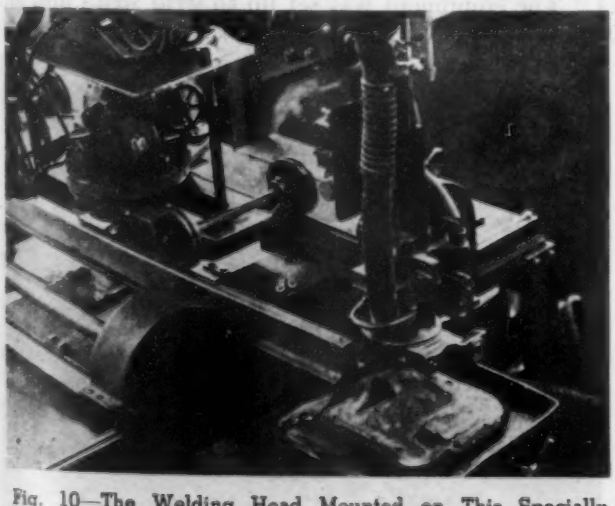

Fig. 10—The Welding Head Mounted on This Specially Adapted Carriage with Crossed Rail Support Was Guided by a Templet to Make a Square Weld

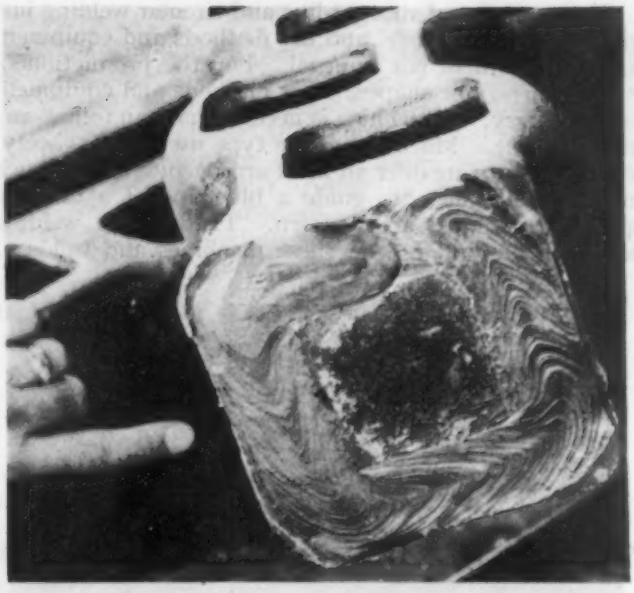

Fig. 11—Closeup of the Square Weld Sealing the End of a Boiler Header

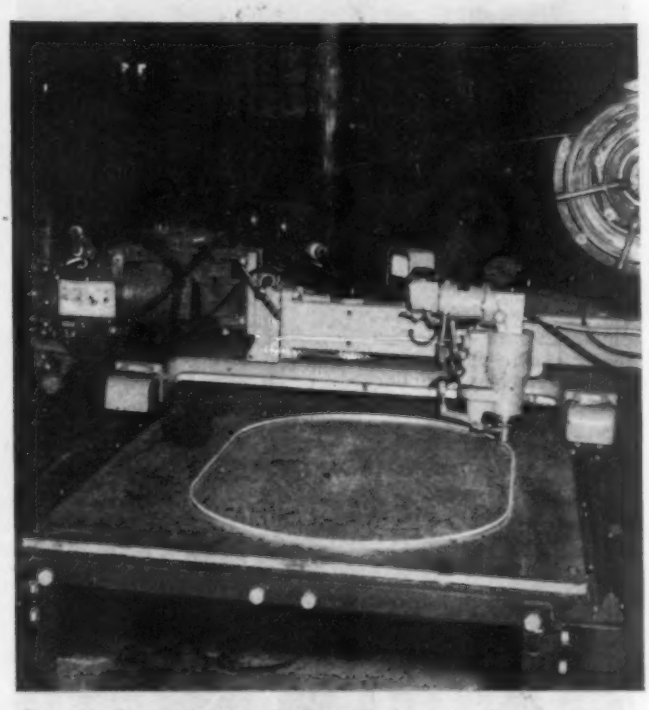

Fig. 12—Shape Welding Fuel-Oil Tanks with a Standard Templet Guided Machine

The examples of straight-line and circular welding just given are fairly simple, and the methods and equipment for making them not unusual. For the production of welds of irregular shapes, other methods and equipment are necessary. A machine is needed that can follow any given outline. Machines of the type used for oxyacetylene shape-cutting offer an ideal arrangement, since such machines are made to guide a blowpipe at a uniform speed over almost any pattern. Therefore, a welding head can be mounted on these machines and welds of various contours made, using a templet for a guide. The laboratory setup shown in Fig. 9 illustrates such an operation.

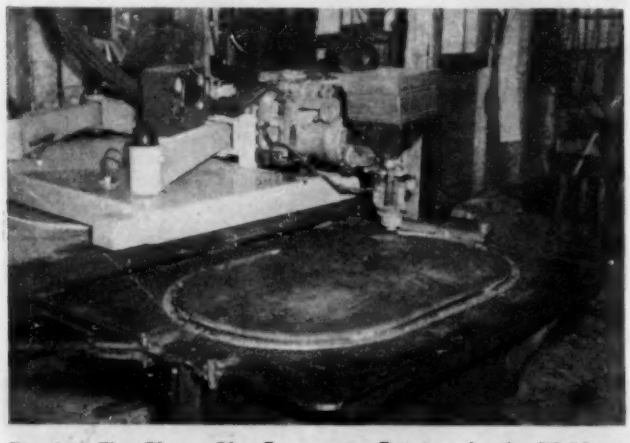

Fig. 13—The Clamp Also Serves as a Retainer for the Welding Composition

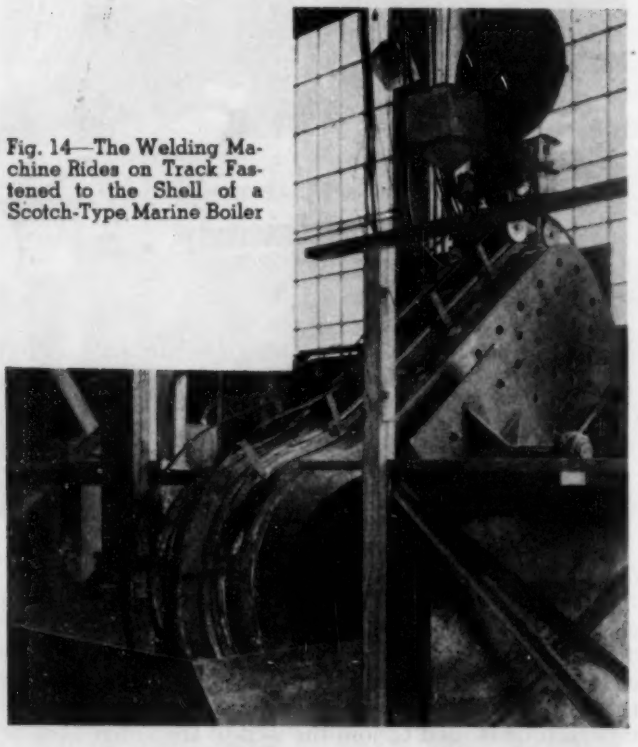

Fig. 14—The Welding Machine Rides on Track Fastened to the Shell of a Scotch-Type Marine Boiler

An adaptation of this method is the making of a square weld to seal the end of marine boiler headers as shown in Fig. 10. The Type U welding head was mounted on a specially built carriage. The carriage rolled forward and back on one pair of rails. These rails were bolted to a truck which rode on a lower set of rails. This provided freedom in the lateral direction. A magnetic tracing unit attached to the underside of the carriage followed the square templet on the table. The welding head was thus driven at constant speed over the square outline required to seal the end of the header. Figure 11 shows the appearance of the weld that was made with this equipment.

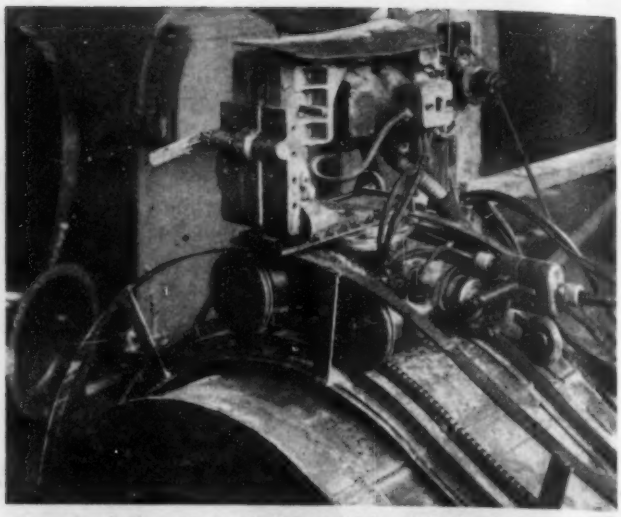

Fig. 15—A Cam-Controlled Switch Controls the Positioning of the Boiler So That the Welding Zone Is Always Horizontal

A manufacturer in the Central States is using a standard machine to shape-weld oval ends to the shells of domestic fuel oil tanks. Figure 12 shows how the equipment is arranged for welding using a strip templet to guide the welding head. The cylindrical shells are pressed into a flattened-oval shape and the flanged ends ends are manually tack-welded in place. The assembly is moved to the welding station and clamped in position as shown in Fig. 13. Edge welds seal the ends to the tank. The clamping fixture also serves as retainer for the welding compostion.

The problem of making shape welds on a surface that is not flat is principally that of synchronizing the position of the weldment with the equipment that supports and moves the welding head. The outline and size of the piece being fabricated will determine the method that must be used. When an irregularly shaped piece is rotated under a welding head in a vertical plane, two problems are at once evident: First, the weldment must be rotated at varying speeds, since the linear speed will vary as the distance from the center of rotation. Second due to the irregular outline, the welding head must travel horizontally and be free to move vertically.

One method of solving these problems is shown in Fig. 14. The equipment was set up to weld strips and side plates to the shells in fabricating a large number of

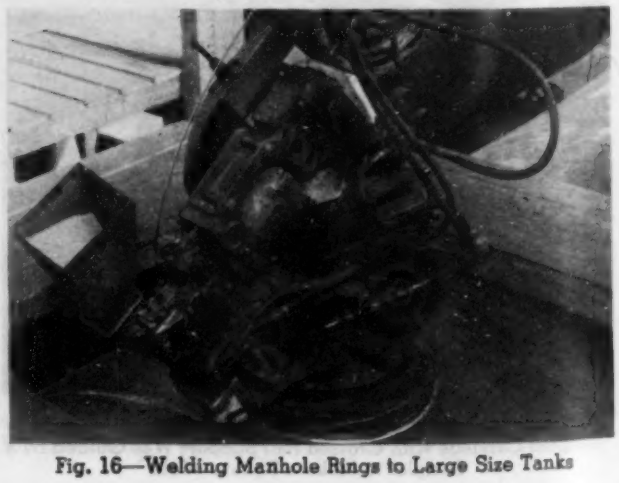

Fig. 16—Welding Manhole Rings to Large Size Tanks

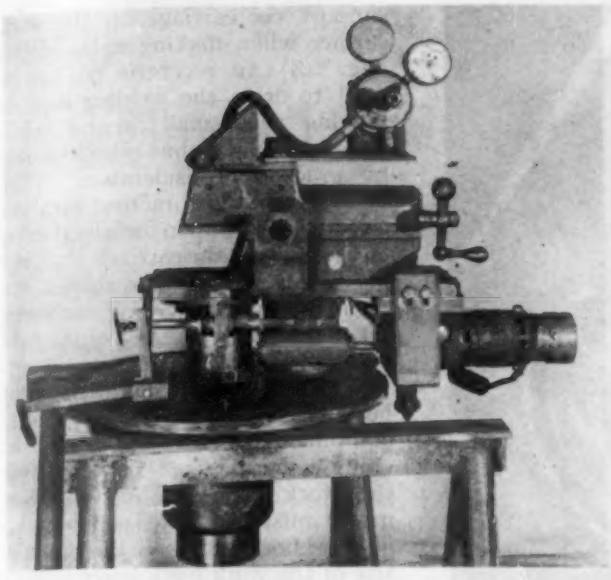

Fig. 17—The Centerpost Assembly Raises and Lowers the Welding Head, Using the Cylindrical Surface of the Tank as a Cam

Scotch-type marine boilers. To insure constant speed, the welding head was supported on a mechanized carriage. Angle iron track was fitted and tacked to the surface of the shell. Positive drive of the carriage was obtained by a sprocket mounted inside the carriage which engaged a link chain fastened to the shell. A trunnion mounting supported the entire boiler and provided rotation in the vertical plane. A variable speed motor automatically positioned the boiler so that the welding zone was always horizontal. A close-up of the welding equipment is shown in Fig. 15. A cam-controlled leveling device mounted on the carriage controlled the operation of the positioning motor. A completed weld is shown in the foreground. Guide rollers are shown riding the welding vee behind and beneath the main cable coupling.

So far, the only welds that lie in both the horizontal and vertical plane are those in which a circular piece is joined to a larger cylindrical piece. The welding of manhole rings to tank car casings is an example of this type of weld. The equipment shown in Fig. 16 was used to weld manhole rings which measure 20 $^{3}/_{4}$ in. O.D., 16 in. I.D., by 2$^{3}/_{4}$ in. thick. In this type of weld,the problem is to provide the head with vertical movement while it is driven in a circle of the proper diameter. The ring is tacked in place and supported from beneath by jacks. A centerpost support is then bolted to the ring. Figure 17 shows the centerpost assembly that was bolted to the manhole ring to support the welding head. The carriage was lifted vertically by a roller, diametrically opposite from the welding head, riding on the shell of the tank. To assist the mechanical lift thus obtained, the welding head was supported on a piston over the centerpost. A three-way pilot valve, controlled by the linkage shown in the foreground, admitted air to the cylinder and alternately raised and lowered the welding head as it passed over the contour. A variable speed motor and gear reduced drove the welding head through a ring-gear bolted to the base plate. The vertical travel was approximately 1$^{1}/_{8}$ in.

It should be noted that the entire tank shell was rolled back and forth as the welding head traveled around the ring so that the welding puddle had no tendency to roll out on the lower sides of the ring. Figure 18 shows this adjustment with the welding head on the low side of the ring.

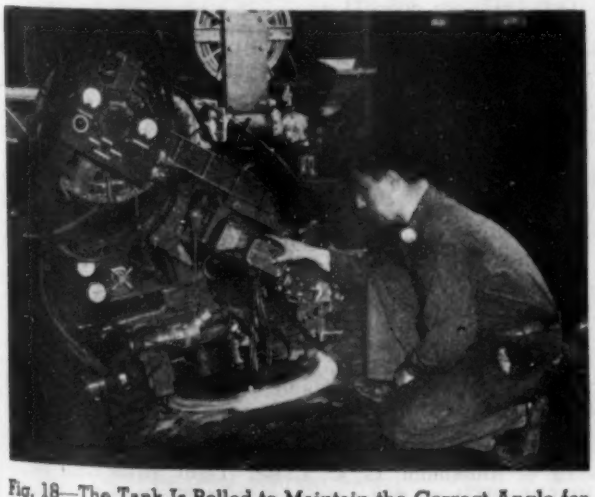

Fig. 18—The Tank Is Rolled to Maintain the Correct Angle for Applying the Fillet Weld

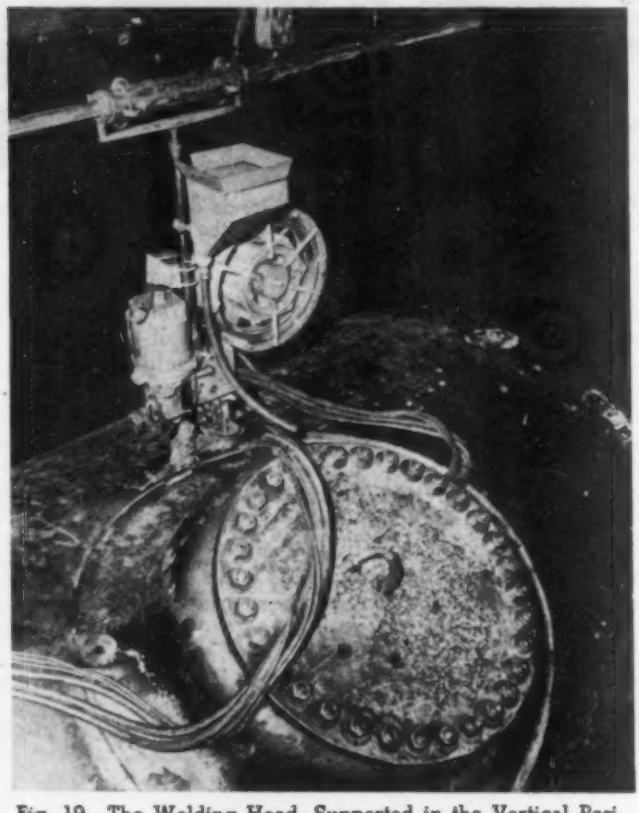

Fig. 19—The Welding Head, Supported in the Vertical Position, Is Guided by the Welding Vee in Welding Domes to Locomotive Boilers

The welding of domes to locomotive boilers presented a similar problem, but it was solved in a different way. Instead of being supported on a central piston, the welding head rested on the work surface. It was tilted in the vertical position and mounted on a small drive unit, as shown in Fig. 19. A vertical post and roller sleeve, riding on a horizontal rod, supported and steadied the welding machine in the vertical position and also supplied the longitudinal motion necessary. As in the previous example, it was necessary to position the boiler under the welding head to keep the welding zone horizontal. A guide wheel roller, riding in the welding vee, guided the machine.

After completing the weld from the outside, the apparatus was then transferred to the inside of the boiler, and rod track was tacked in place to guide the welding ma-

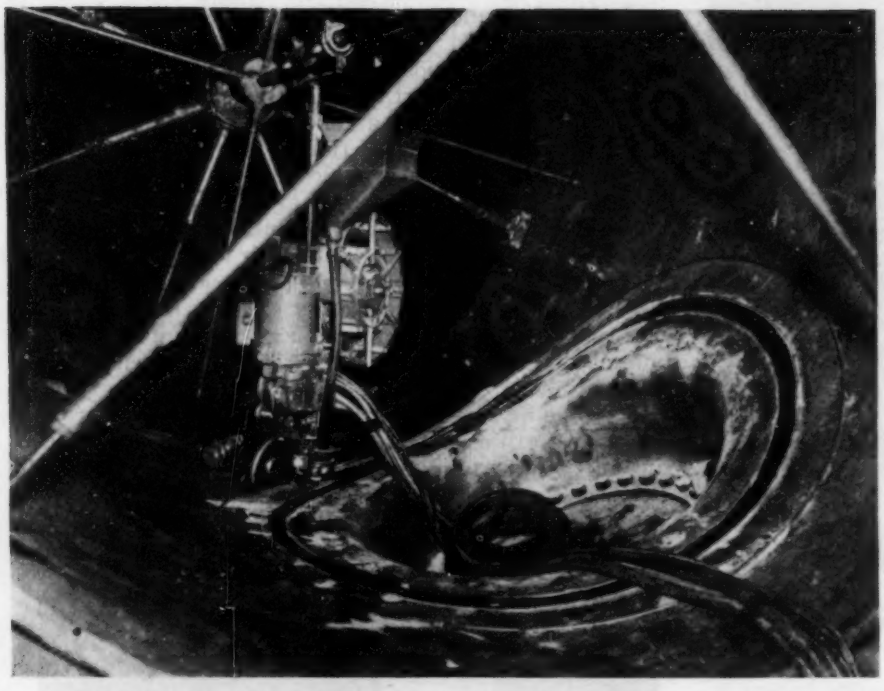

Fig 20—Welding Rod, Tacked to the Inside of the Boiler, Guides the Welding Head When Making the Inside Weld

chine as shown in Fig. 20. This view also shows how the overhead support was braced to the walls of the locomotive boiler shell. The entire welding machine was free to turn about the vertical support. A small grooved guide wheel, mounted a few inches behind the large drive wheel, kept the welding machine in line with the track.

To summarize, the problems of shape-welding have so far been solved by the following devices: (1) For large circular welds, when it is not practical to use a radius rod, the carriage can be driven in a circle by guide wheels resting on such natural guides as hubs or flanges. (2) For smaller flat circular welds, the carriage can be driven in a circle by the use of a radius rod. It is necessary to support the carriage on the work surface when making welds of this size. (3) An eccentric pin can be used to drive the welding head in making very small circular welds. The minimum radius is limited only by practical consideration. The maximum radius practical with this device depends upon the lateral swing of the arm on the carriage. (4) For flat welds of irregular shapes, the use of a templet following machine is recommended. The size of the weld is limited by the capacity of the cutting machine. (5) For welds that lie in the vertical plane, the simplest equipment consists of a track to guide a mechanized carriage over the work surface. A positioning motor must be used to keep the welding zone horizontal. In this case, the size of the work has a lower limit in relation to the size of the welding machine. (6) The work surface can be used as a cam to raise and lower the welding head in making welds that lie in both horizontal and vertical planes. (7) Another method for making horizontal-vertical welds is to support the welding head separately so that longitudinal movement is provided, while the work piece is rolled under it to provide lateral travel. Guiding is obtained by the welding vee or a rod track tacked to the work surface.

As welding engineers realize the possibilities of shape-welding methods, there will undoubtedly be many other applications. The methods used will probably be similar to those described, and, of course, some totally new methods will be devised to solve special problems of guidance and positioning. The principal factors that will determine the method that will be used will be the shape of the weld, the size of the weldment and the number of units to be made.

Current Welding Literature

Bath Tubs. Manufacture. Press-Shaping Bath Tubs. Steel, vol. 121, no. 16 (Oct. 20, 1947), pp. 90–91.

Brazing, Aluminum Alloys. Torch Brazing Aluminum, H. A. Huff. Welding Engr., vol. 32, no. 5 (May 1947), pp. 57–61; see also Western Machy. & Steel World, vol. 38, no. 7 (July 1947), pp. 88–92; no. 8 (Aug.), pp. 80–84.

Brazing, Cast Iron. Design Possibilities in Silver Brazing of Cast Iron, H. Frick. Product Eng., vol. 18, no. 10 (Oct. 1947), pp. 128–132.

Brazing, Electric. Carbon Brazes Copper Parts, W. Scott. Am. Mach., vol. 91, no. 23 (Nov. 6, 1947), pp. 98–100.

Brazing, Electric. Methods for Placing Brazing Materials and Vent Locations. Product Eng., vol. 18, no. 7 (July 1947), pp. 124–125; no. 8 (Aug.), pp. 120–121.

Brazing. Furnace Brazing. Automobile Engr., vol. 37, no. 493 (Oct. 1947), pp. 365–371.

Car Building, Welding. Steel Mineral Wagon Construction at L. M. S. Works. Engineer, vol. 184, no. 4785 (Oct. 10, 1947), pp. 339–341; see also Engineering, vol. 164, no. 4264 (Oct. 17, 1947), pp. 367–368, figs. p. 372.

Car Building. Welding Railroad Passenger Cars, A. M. Unger. Welding Engr., vol. 32, no. 10 (Oct. 1947), pp. 44–48; no. 11 (Nov.), pp. 36–39, 43.

Casting vs. Welding. Conversion to Welded Construction, O. Blodgett. Welding Engr., vol. 32, no. 10 (Oct. 1947), pp. 33–41.

Cars, Freight. Large-Scale Manufacture of Wagons, L. M. S. R. Ry. Gaz., vol. 87, no. 14 (Oct. 3, 1947), pp. 374–378.

Coke Ovens, Pushers. Redesigned Wheel Mounting for Coke Oven Pusher, J. H. Kincaid. Can. Machy., vol. 58, no. 9 (Sept. 1947), pp. 171, 174, 176.

Conveyors, Screw. All-Welded Grain Loader. Welding Engr., vol. 32, no. 11 (Nov. 1947), p. 51.

Crankshafts Maintenance and Repair. Bingham Sleeving Process—Method of Crankshaft Repair. Motorship, vol. 32, no. 9 (Sept. 1947), pp. 26–27.

Electric Welding, Arc, Aluminum. Argon Shielded Metal Arc Welding of Aluminum, G. C. Close. Light Metal Age, vol. 5, no. 10 (Oct. 1947), pp. 6–9.

(*Continued on page 35*)

Flame-Hardening Machine Tool Parts*

By W. D. Whalen†

Flame-Hardening Machine Tool Parts

OXYACETYLENE flame hardening is one of the newer methods for selective surface heat treatment. As the name implies it makes use of the intense heat of the oxyacetylene flame, or group of flames, to rapidly raise the surface of a part above the critical temperature. The surface is then rapidly cooled, that is quenched, with a resultant increase in hardness due to the internal structure change. This method of selective surface heat treatment is quite widely used in the machine tool and allied heavy industry. It gained much favor during the war, as it was quite extensively used for the surface heat treatment of many tank, truck and heavy artillery parts.

Methods of Flame Hardening

There are four basic methods of flame hardening and each will be described briefly. Examples of each method will be shown later on.

The first method, which is the easiest and most elementary, is the spot hardening method. It consists merely of holding an oxyacetylene flame or group of flames over the spot or area, which it is desired to harden, for a given period of time until the area has reached the proper quenching temperature and then quenching.

The second method is the spinning method. It is confined to cylindrical parts, and is accomplished by arranging a burner or group of burners around the peripheral surface of the part to be treated. The part is revolved within this ring of burners at a rate which will give a surface speed of around 800 to 1000 in. per minute. The surface speed depends, to a certain extent, upon the size of parts, nature of the surface and the depth of case desired. For this method of flame hardening, the burners usually do not have the quench orifices included in them as do those for progressive hardening. The quench is usually obtained by using either a separate spray head for spray quenching the work after the surface has reached the proper temperature or by transferring the work after it has been heated to a separate quench tank.

The third method is the progressive method. For this method of flame hardening the burner is moved along, at a given distance from and at a uniform rate over the surface to be flame hardened. There may be some cases, however, when it would be more desirable to hold the burner stationery and move the piece to be treated under the burner. Either way is satisfactory. This type of flame hardening is applicable to almost any work where the shape and size are such that the burner can be made to cover the area desired to be hardened. The most general application is to straight flat work. The burner for this method of flame hardening is usually of the combination type, that is, the flame orifices and the orifices for the quench are built into one body, the quench orifices being a short distance in back of the flame orifices. From these orifices, the quench medium is sprayed upon the hot surface of the metal. The rate of travel of the burner and quench will vary with the design of the burner, material being treated, the depth of case desired, etc. It usually is somewhere within the range of 4 to 10 in. per minute.

The fourth method is the combination method. This method, as its name implies, is a combination of the progressive and spinning method. It is generally applied to long cylindrical shafts or cylinders. The burner, or group of burners, are spaced around the periphery of the shaft in much the same manner as used for spin hardening. The work is rotated at a rate to give a surface speed of approximately 1000 surface inches per minute. At the same time, the burners are moved progressively along the work surface. The rate of travel depending upon the size of the work being treated, the nature of the surface, the depth of the case desired and the size of the burner. The quench is usually of a spray or jet type and can be included in the design of the burners or it may be applied from a circular quench head which will immediately follow the burners. The size of parts that can be treated by this method depends almost entirely on the capacity of the equipment available.

Materials That Can Be Flame Hardened

We might say in general that any steel or ferrous material that can be hardened by the normal furnace method can also be flame hardened. Steels having a carbon content of at least 0.35% carbon can be flame hardened, although better and more uniform results will be obtained if the carbon content is above 0.40%. The degree of hardness obtained on the surface depends on two main factors: (1) The carbon content, and (2) the drasticness of the quench. Plain carbon steels can and are being flame hardened regularly. They are quite satisfactory where surface hardness alone is the primary requisite. However, medium carbon-alloy steel, such as the nickel-chromium, the molybdenum-chromium or the newer triple alloy steels, are considered essential where, in addition to a high surface hardness, the part must have high strength to resist the stresses or shock loads it may be subjected to in service.

The degree of uniformity of hardness and uniformity of depth of penetration of the case depends also very much on the combination and quantities of alloys present in the steel. The common alloys, that is, chromium, nickel and molybdenum, used in various quantities and combinations in the regular constructional

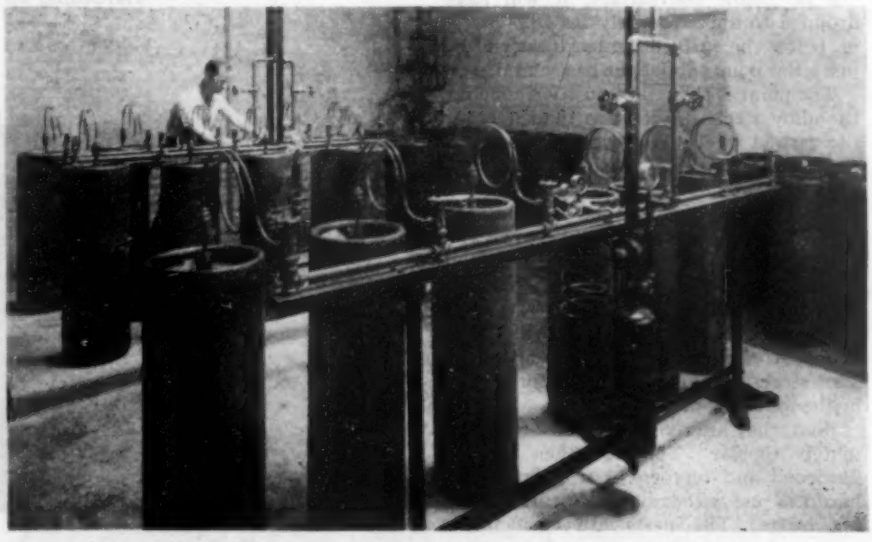

Fig. 1—Acetylene Manifold Room. Showing Arrangement of Manifold and Acetylene Cylinders

* Paper presented before the 47th Annual Convention of the International Acetylene Assoc., Cincinnati, Ohio, May 20–21, 1947.

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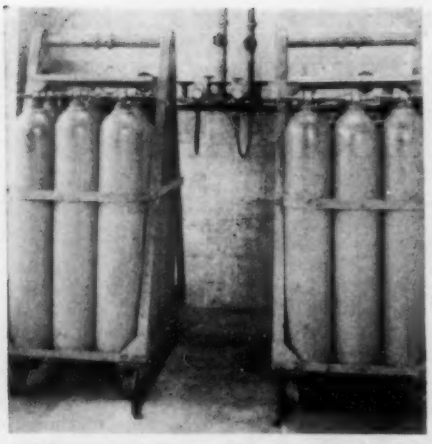

Fig. 2—Oxygen Manifold Arrangement. Each Dolly Holds 15 Cylinders, All Interconnected to One Single Outlet. Only One Connection from Each Dolly to the Manifold Is Required

alloy steels all have the effect, in a complex way, of increasing the depth and degree of hardness obtained on heating and quenching. Therefore, the transition zone from the soft base metal to the fully hardened case is much narrower for an alloy steel than it is for a plain carbon steel.

To illustrate this point, a plain carbon steel of 0.45% carbon flame hardened under operating conditions such that a 1/8 in. depth of heat penetration would result, and using a spray water quench would probably have a surface hardness of Rc-58. At a point, say 1/16 in. below the surface, the hardness will only be in the neighborhood of Rc-35 to 40 and at 3/32 in. below the surface it will have dropped to Rc-30 or less.

On an alloy steel, say of the chromium-molybdenum type, of the same carbon content as above and flame hardened under operating conditions such that a 1/8 in. depth of heat penetration would result and also spray water quenched, the surface hardness would be Rc-58–60. However, here when the hardness is checked through the case, it will be found that at 1/16 in. below the surface, the hardness will still be almost as high as it was at the surface, probably about Rc-54. At a point 3/32 in. below the surface, it will have dropped to approximately Rc-48. At 1/8 in. below the surface the hardness will be just a few points above the base metal.

The point is that the transition zone for the alloy steel is much less than it is for the carbon steel. However, there nevertheless is a definite transition zone of possibly 0.030 to 0.040 which is very beneficial. It is generally recognized and agreed that a fairly broad transition zone between the hard case and the core is quite essential for parts which are subjected to high shock or fatigue loads.

Quite frequently parts that will be severely stressed in service are made of an alloy steel such as A-4142 and are processed in the following manner.

First, they are rough machined approximately to size. They are then furnace hardened and tempered, or drawn, to a hardness just within the practical machining range. The parts are then finish machined accurately to size and the wearing surfaces are flame hardened. This

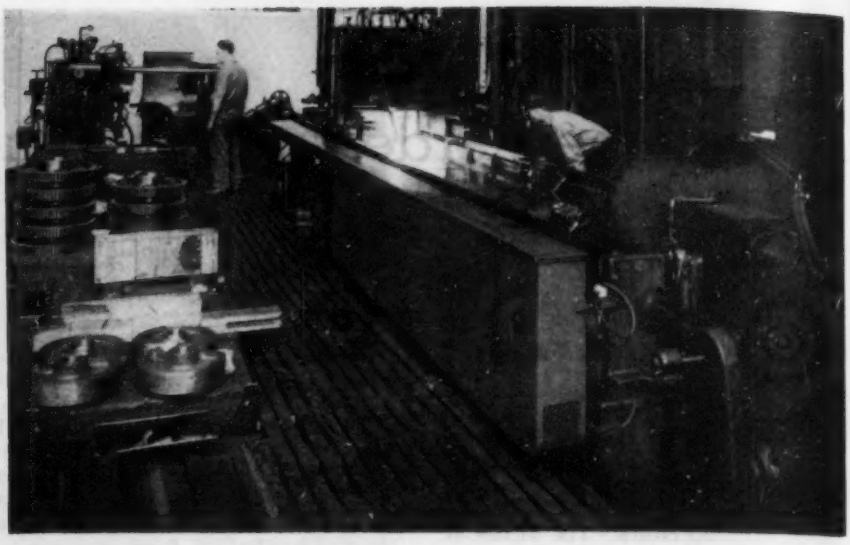

Fig. 3—A Portion of Our Flame Hardening Department. Showing the LeBlond Built Universal Flame Hardening Machine in the Right Foreground and the Fellows Flame Hardening Machine in the Background

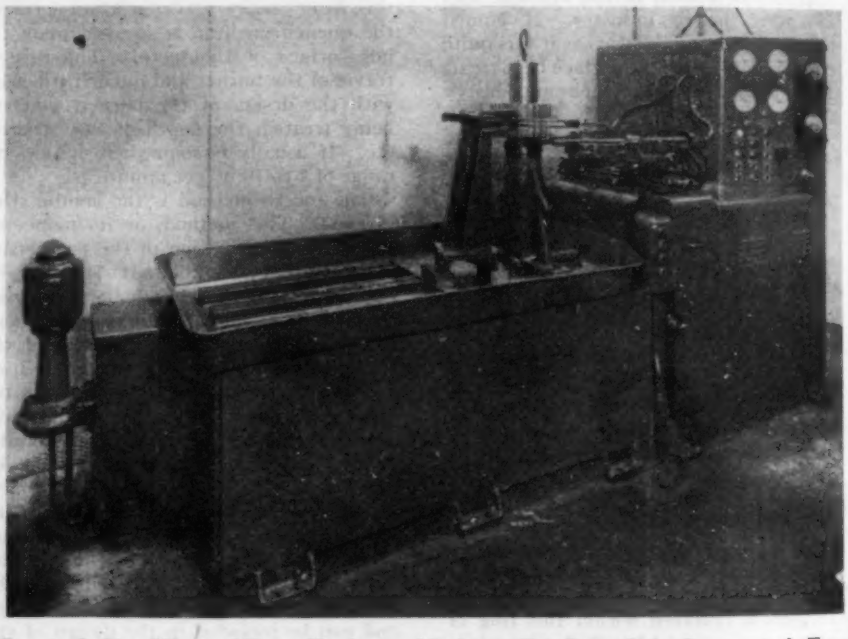

Fig. 4—LeBlond Vertical Flame Hardening Machine. This Setup Is for Progressively Flame Hardening the Teeth of a Large Gear

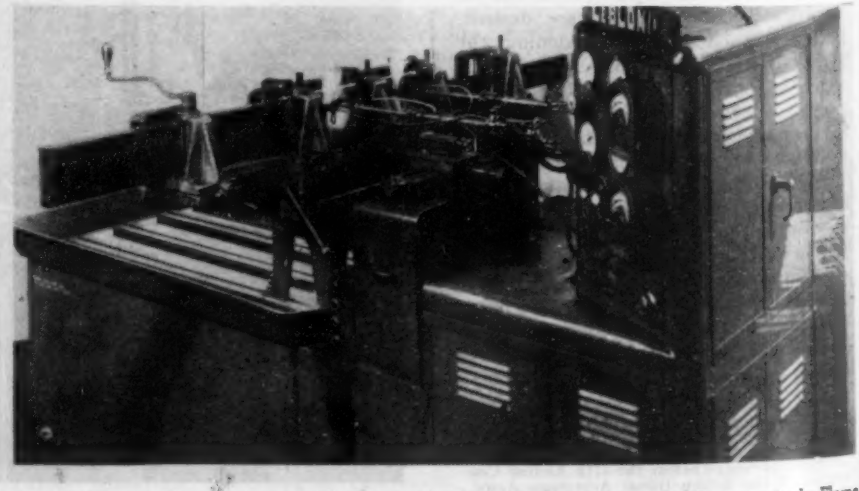

Fig. 5—The LeBlond Vertical Flame Hardening Machine, Setup for Progressively Flame Hardening the Teeth of Racks

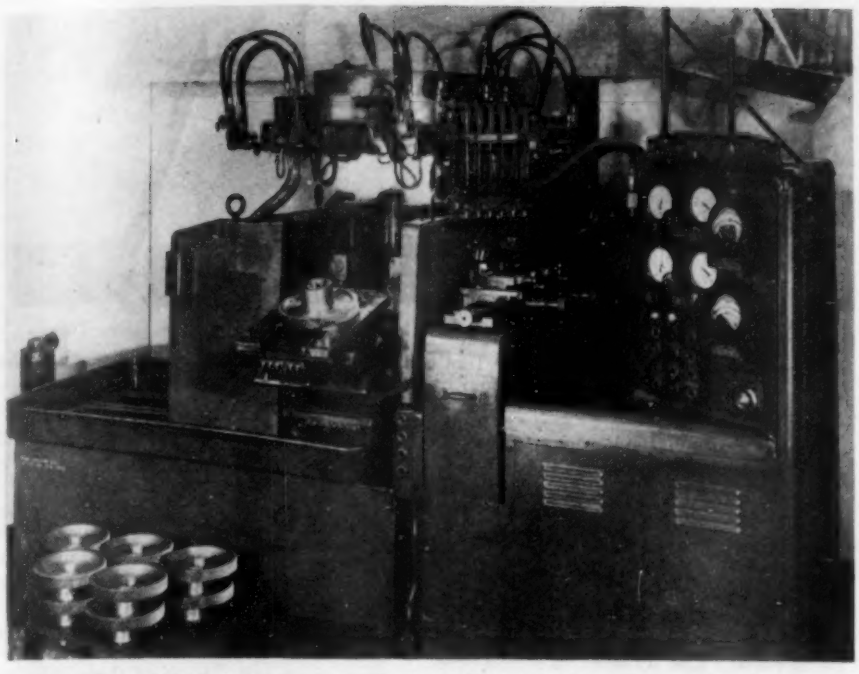

Fig. 6—A Special Attachment on the LeBlond Vertical Flame Hardening Machine for Automatically Flame Hardening Gears by the Spinning Method. With This Set-Up the Cycle of Operation Is Completely Automatic. It Is Only Necessary for the Operator to Place the Gear on the Convenient Loading Platform at the Front of the Machine

procedure gives a very hard wear resisting case backed up by very tough high strength core which will withstand high shock and fatigue loads.

Cast iron, as well as steel, can be and is very widely being flame hardened. Plain cast irons can be flame hardened, but to get good uniform results the inclusion of one or more alloys in the iron is almost an essential. The alloys used are generally one of the following combinations: chromium-molybdenum, nickel-chromium or nickel-molybdenum. The effect of these alloys in the cast iron are somewhat similar to their effect in steel, as far as reacting to a heat treament is concerned. They all tend to increase the degree of hardness and the depth of hardness to a more or less extent.

As with steel, the hardness obtained on cast iron is dependent, more or less, on the combined carbon content. The minimum combined carbon content should be around 0.60% and the minimum manganese content of around 0.70% plus one or more of the above alloys for most successful results.

Skill and Equipment Required

As you no doubt have gathered by now, flame hardening is basically a science and being a science, a certain degree of skill is required of the operator to obtain the best results. No manufacturer should consider going into flame hardening without obtaining the best of equipment and control instruments. In addition, he should consider, and be willing to do some basic experimental work on each part before he starts it into production. He should not consider flame hardening with makeshift equipment any more than he would consider setting up a forge in a modern heat-treat department to be used for the heat treatment of intricate tools and dies.

There have been cases where flame-hardened parts have not given the anticipated results in service. Quite frequently the manufacturer or the individual in charge immediately condemns the flame-hardening process. Whereas, in most cases where a through investigation has been made, the failure of flame-hardened parts was traced to either the flame-hardening process not being properly performed or the wrong selection of a grade or type of material for the given part. Again, there are other times when flame hardening should not have been employed, due to the size or nature of the part or the service to which it was subjected. Flame hardening is not a cure-all.

A source of oxygen and acetylene is the first basic requirement for flame hardening.

Figure 1 shows the arrangement of the acetylene manifolds in our acetylene room. Since this picture was taken, another bank of cylinders have been added to the manifold in the foreground, giving us two complete manifolds of 12 cylinders each. The piping from these manifolds to the individual machines is so arranged that each machine can be operated from any one group of manifolds or from the whole group of manifolds. The number of manifolds to be used depends on the amount or volume of acetylene needed at the invididual machines for the operation being performed.

The source of acetylene is a point which should be very carefully investigated by a manufacturer who is considering flame hardening on a large scale. The first thing would be to make an estimate of the volume of acetylene that will be used; allowing a reasonable extra margin for future expansion, because no doubt as time goes on many additional parts, or more particularly new design parts, will be flame hardened. To make an accurate approximation of the volume of gas required is not an easy task, for there are several points to consider. First would be the method of flame hardening, i.e., whether spinning or progressive, as progressive flame hardening is usually more efficient than spin flame hardening. However, this depends on the nature of the surface, the depth of case desired, the design of the burner, etc.

We have found that for single flat surfaces flame hardening progressively to a $^1/_8$ in. depth of case requires between 0.3 and 0.4 cu. ft. of acetylene per square inch of area. For progressively hardening three adjacent surfaces of a rectangular bar of the type shown in Fig. 11 requires between 0.2 and 0.3 cu. ft. per square inch of area for a $^1/_8$ in. depth of case. The volume used will vary almost directly with the depth of case.

After the approximate volume of gas required has been determined the point

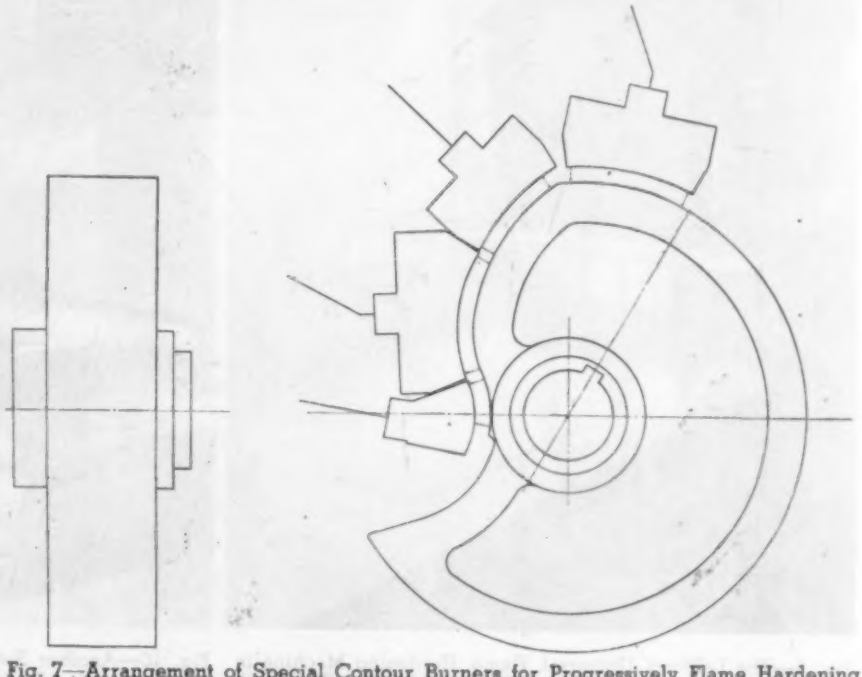

Fig. 7—Arrangement of Special Contour Burners for Progressively Flame Hardening Contour of a Crankshaft Lathe Cam

to consider is, should cylinder gas on a manifold such as shown in Fig. 1 be installed or would it be more efficient and economical to install an acetylene generating station? There are many angles to this question, such as possible location of a manifold room or generating station with respect to location of the flame-hardening machines, amount of piping necessary for each method, cylinder handling cost as compared to operating a generating station, etc. When making a study of these and various other points a qualified representative from an acetylene producing company should be consulted.

Figure 2 shows our oxygen manifold room. Notice here that we have a single manifold to which can be attached two of the oxygen dollys. Each of these dollys have 15 oxygen cylinders interconnected together on them and all are connected to a single outlet. So by use of this arrangement we can change the equivalent of 15 cylinders on a manifold by just making one connection. When the cylinders on one of these dollys is empty, it is only necessary to break one connection, roll the empty dolly out and replace it with a dolly of full cylinders, making one connection and resume operation.

The nature of the source of oxygen should also be carefully investigated, i.e., whether to use a manifold and individual cylinders, or a dolly with a group of cylinders as shown here, or an oxygen bank which would be maintained above a certain minimum limit at all times. This latter method eliminates the necessity of cylinder handling altogether. In any event the advice and suggestions of a local oxygen producing company should be requested.

We have three flame-hardening machines in operation at the present time, two of which were designed and built by LeBlond. The third is a commercial machine made by the Fellows Gear Shaper Co. It is suitable for hardening gears up to 12 in. in diameter by the spinning method only. The machines built by LeBlond are what might be termed Universal Machines, in that either spinning or progressive type of work can be performed on them.

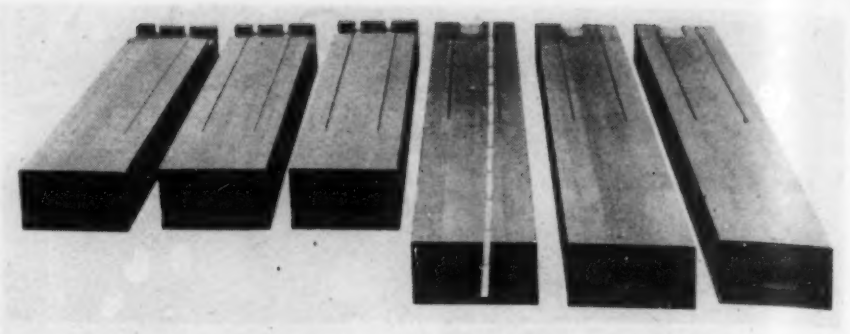

Fig. 8—Automatic Crankshaft Lathe Tool Bars on Which Portions of All Four Sides Are Flame Hardened by the Progressive Method

The first flame-hardening machine built by LeBlond is shown in Fig. 3 in the right foreground. The Fellows spinning machine is in back. This machine is made in three major units. One is the lower tank which is water tight. The second unit is the upper tank which sets on top of the lower tank and is fastened rigidly to it. The third is the carriage or torch-carrying unit. The reason for the double tank arrangement is so that when you change from one quenching medium to another, as from straight water to soluble oil, it is not necessary to dump the soluble oil solution, but instead it can be drained into the lower tank. The upper tank can then be filled with straight water when it is required for the quenching medium. Then when another type of job comes along on which a soluble oil quench is required the straight water from the upper tank is dumped to the sewer and the soluble oil solution is pumped from the lower tank into the upper tank. This way it can be used over and over.

The carriage is mounted on antifriction bearings and rides on and is guided by the finished surfaces on the side rails of the upper tank. As can be noted, the carriage has provisions for holding five torches at one time, each torch being held by an individual slide which is fitted on a common cross rail. Each of these slides can be raised or lowered individually and they can be swiveled to any desired angle.

At the head end of the machine can be seen the headstock and motor drive. The motor is a d.-c. variable speed type and drives the spindle through a gear train. From the spindle there is a set of pick-off gears which drive a lead screw. The carriage is connected directly to this screw, so there is positive uniform movement of the carriage. The desired rate of travel of the carriage is set by means of the variable speed motor.

The headstock spindle is hollow and a universal or air-operated chuck can be mounted on it for holding parts which are to be flame hardened by the spinning method.

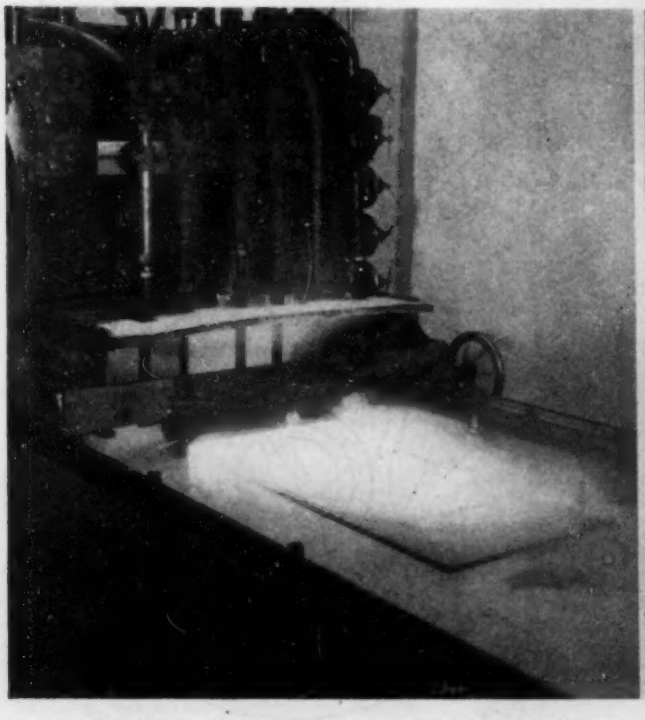

Fig. 9—The LeBlond Universal Flame Hardening Machine in Operation on One of the Tool Bars Shown in Fig. 8. The Width of the Surface Being Flame Hardened Is 16 In.

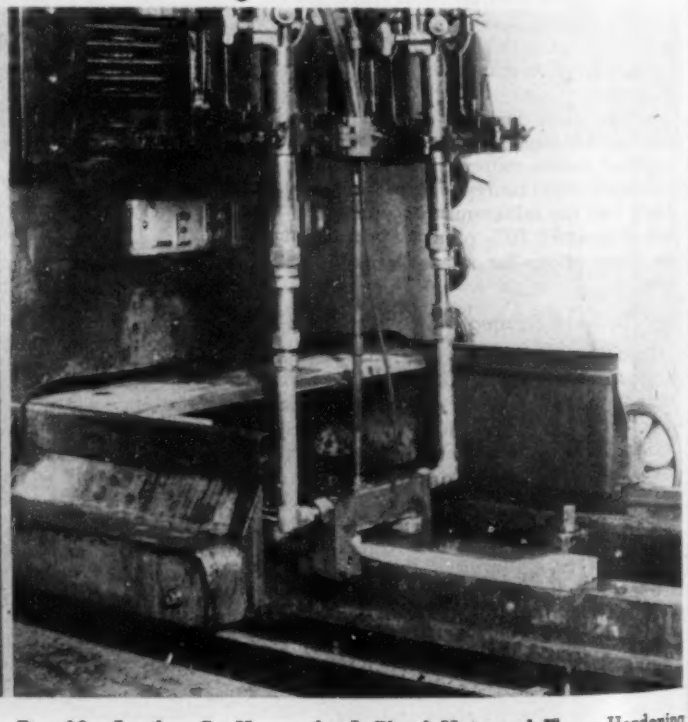

Fig. 10—Another Set-Up on the LeBlond Universal Flame Hardening Machine with a Special Burner for Simultaneously Flame Hardening the Two Edges and Top Surface of a Lathe Bed Wear Strip

The carriage has a travel of 15 ft. 11 in. and the width of the tank is such that a part having a flat surface up to 20 in. in width can be hardened. Parts up to 34 in. in diameter can be set between centers.

Also note that each torch has an individual pair of regulators, that is, one oxygen and one acetylene. A mechanical timing device is incorporated in the design of the apron so that any amount of predetermined dwell can be set.

Figure 4 shows the last machine built. It is known as the vertical flame-hardening machine because the burners travel in a vertical plane rather than a horizontal plane. This machine is adaptable to all four methods of flame hardening. That is, parts can be flame hardened, with the aid of suitable attachments, by either the spot, progressive, spinning or combination methods. The end results desired and the size and nature of the parts to be treated will determine which method to use.

The machine is electrically controlled and by means of a selector switch can be made fully automatic or semiautomatic in its operation.

This photo shows the machine set up for progressive hardening the teeth of a wide-faced gear. Rack teeth can be progressively flame hardened with the aid of the attachment shown in Fig. 5 on this machine. For these setups, the burners progress vertically along the teeth, two teeth being treated at a time. The automatic cycle for this operation would be as follows:

After the operator had indexed the rack or gear to the set of teeth to be treated, he would just have to press the start button on the control panel. The burners would rapidly advance up to the edge of the teeth where they would stop, light up and dwell for a predetermined time so that the ends of the teeth would be at the proper quenching temperature. The burners would then progress along the teeth until they reach a very short distance from the top edge of the teeth, at which point they would be extinguished. Then they would rapidly advance the remaining short distance to the end of the tooth and dwell for a predetermined set period so that the ends of the teeth would be thoroughly quenched. The burners would then rapidly return to the starting position. The operator would then manually index to the next set of teeth and the automatic cycle would be repeated. Figure 6 shows an attachment on this machine for flame hardening smaller size gears and cylindrical parts by the spinning method.

When the spinning method is used, this machine is entirely automatic. The conveyor platforms, one front and one rear, move the gear through the complete hardening cycle. The operator is required merely to place the parts to be treated on the convenient front platform. This platform moves the parts to a position over a spindle. The spindle raises up, lifts the part off the platform and starts to spin. It continues to raise until the gear is in the circle of flames from the burner. It will remain spinning in this position for a predetermined set time to heat the periphery to the proper quenching temperature.

The time interval is determined by a number of factors, among which are the number of burners used in relation to the size of the part being treated, the number of flames per burner, the distance the burner is set from the work being treated, the depth of case required, etc.

While the spindle is in the raised position and the work is being heated, the loading, or front platform, has returned to the starting position, and the rear, or unloading platform, has moved to a position around the spindle. When the proper temperature is reached the spindle recedes. The rear platform strips the heated part off the spindle and conveys it to the quench medium contained in a tank at the rear of the machine. In the meantime, the operator has placed another part on the front platform which moves up into the position over the spindle as the rear platform conveys the heated part to the quench tank. There is a chain conveyor in this quench tank which lifts the part out of the quench medium to a platform where they may be removed at the operators convenience.

Distortion

Whenever any hardenable material is heated above a critical point and quenched or cooled at such a rate that martensite is formed, there is a definite volume change. The amount of this volume change depends to a considerable degree upon the following:

1. The chemical analysis.
2. The physical condition of the bar previous to the heating and quenching, that is, whether it had high residual stresses in it from previous hot or cold working.
3. Previous thermal treatments.
4. The drasticness of the quench and the volume of metal quenched.

The direction or the way in which this volume change will go depends principally on the design and shape of the part, the section sizes and the method by which it was quenched.

With flame hardening we still have this volume change when the martensite is formed in the surface layer. However, due to the fact that we are only heating or transforming a very thin layer near the surface, the degree of amount of volume change is not nearly so great as it would be if the part were heated and quenched all over. For parts of a fairly heavy section the physical strength of the core or base metal is great enough to overcome the forces set up by the hardened layer trying or tending to expand. Experiments have shown that the stresses between the hard and the soft metal of a flame-hardened part are in the neighborhood of 30,000 psi., for a medium carbon-alloy steel such as S.A.E.-4145. They are in the neighborhood of 16,000 psi. for an alloy cast iron. Experiments have also been conducted that show that these stresses can be reduced approximately 40 to 50% by giving the part a stress-relieving draw or temper at 375 to 400° F. However, there are

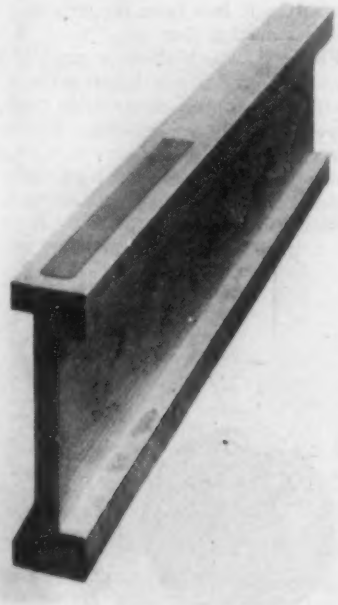

Fig. 11—A Slide for Carrying a Cam Bar on an Automatic Crankshaft Lathe. This Slide Is Made of Alloy Cast Iron and the Edges and Adjacent Flat Surface of Both the Top and Bottom Are Flame Hardened

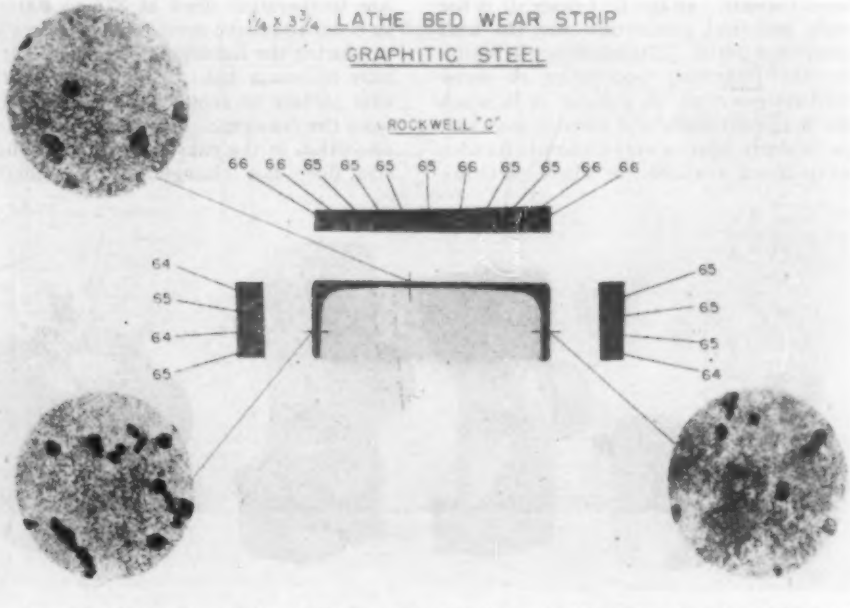

Fig. 12—The Penetration Pattern, the Resulting Hardness and the Microstructure Obtained on Flame Hardening a Graphitic Steel Lathe Bed Wear Strip

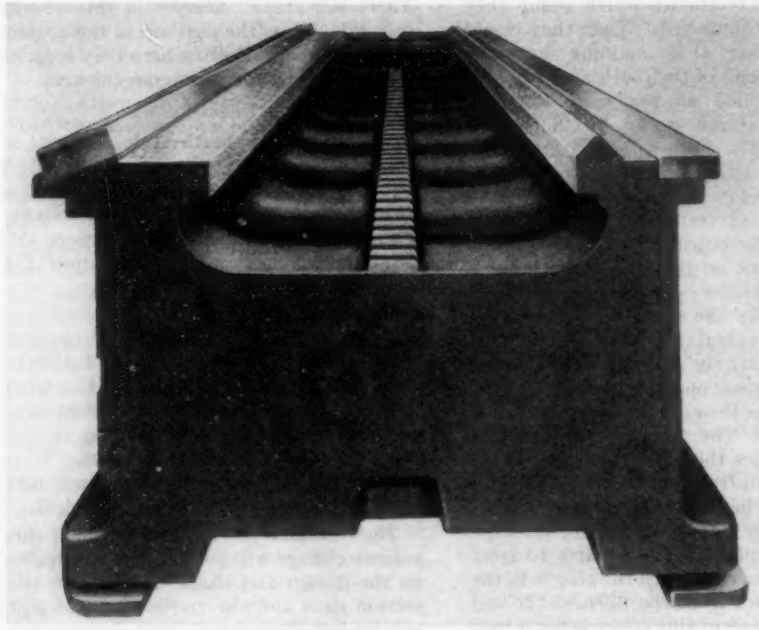

Fig. 13—A Heavy Duty Lathe Bed Showing the Flame Hardened Graphitic Steel Wear Strip in Place on the Ways

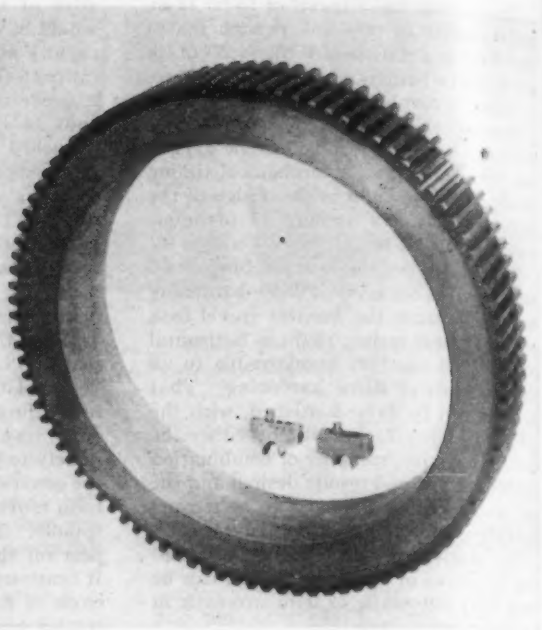

Fig. 14—A Large Ring Gear and the Individual Burners for Progressively Flame Hardening the Contour Surfaces of the Teeth

parts where even this amount of stress may be detrimental because of the nature of the loads to which they would be subjected to in service. Service stresses may cause them to distort further. With the flexibility of the flame-hardening process it is many times possible to balance these stresses by turning the part over and flame hardening an area on the opposite side. In all cases, if the part to be flame hardened is made of cast iron, cast steel or heavily forged steel, it should be given a thorough normalizing or annealing treatment previous to flame hardening to equalize and relieve the castings and forging stresses set up.

Examples of Flame-Hardened Parts

Flame hardening will become more widely used and will continue so for two main reasons. In the first place, it is the most practical production way to heat treat some parts. The second main reason for the increasing popularity of flame hardening is that, in general, it is much less time-consuming and more economical, particularly where a very elaborate furnace setup is not available, or where parts are run in small quantities at intermittent intervals. Some examples of these two points will now be given.

Figure 7 illustrates the burner setup for hardening the working surface of a crankshaft lathe cam. Here special contour burners have been designed to suit the contour of the working surface of the cam. The cam is machined very accurately to the desired contour, and the hole is accurately bored to size in the proper relation to the cam surface. It is then flame hardened by the progressive method with the burners illustrated. The burners passing progressively across the face of the cam at a rate of about 4 in. per minute. The width of the cam face is 4 in., so that including the dwell at the start, it takes only approximately a minute and a half to harden the working area of this cam. The cams, after flame hardening, are given a low temperature draw at 375 to 400° F. in order to relieve some of the stresses set up during the hardening operation. It is only necessary then to lightly polish the cam surface to remove the discoloration from the drawing. There is no noticeable distortion in the cam contour. The hole size does not change any appreciable amount during the flame-hardening operation. Therefore, the hole can be bored accurately to size before heat treating and the cam surface can be machined from the finished hole. This is very desirable because these cams operate in pairs and it is necessary that the two match perfectly.

Before the advent of flame hardening we had to furnace harden these cams and then draw them to a hardness of approximately 300 Brinell. This was necessary so that we could finish machine them accurately to size after the hardening operation in order to overcome the distortion encountered. In service these cams at this hardness did not hold up as well as they should. In addition to this, gear teeth are cut in the lower 160° of the circular portion of the cam after it has been properly matched with its mating cam.

Figure 8, which shows a group of tool bars used on our crankshaft lathe, is another good example of the above two main reasons for the use of flame hardening. There are also other bars used on our crankshaft equipment which are similar to these. These bars may vary anywhere in cross-section size from $2^1/_2$ x $7^1/_2$ in. up to $7^1/_2$ x 16 in. and in length from 2 to 5 ft.

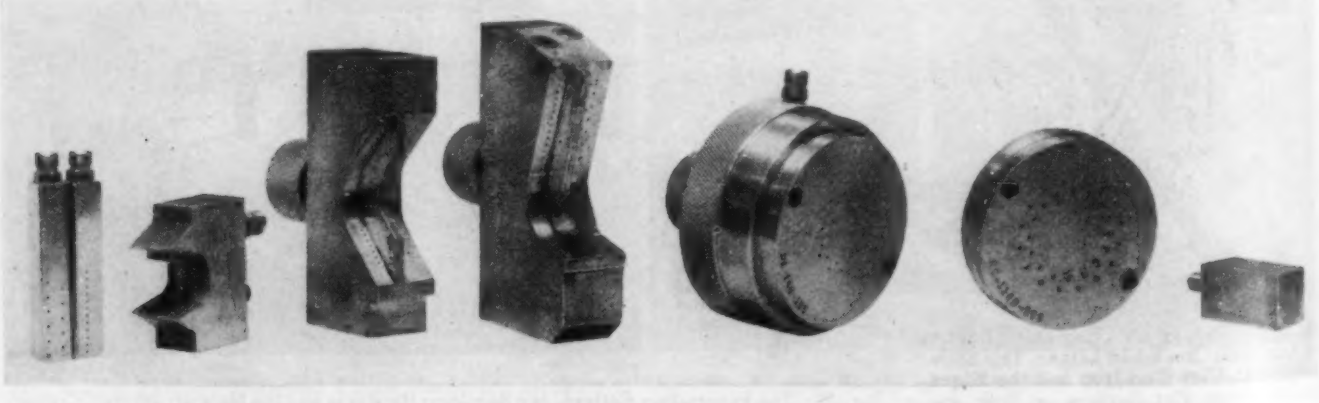

Fig. 15—A Representative Group of Special Shape and Sizes of Flame Hardening Burners

The smaller size bars are made out of S.A.E.-4140 forgings and the larger size bars are made out of S.A.E.-4140 steel castings. As can be noted, the steel castings have a considerable portion of the center cored out in order to reduce the weight and cost.

Our problem was to selectively surface harden all four sides of these bars, leaving short distances near each end soft for future machining and fitting operations. The bars must be uniformly hard over the entire width and depth clear out to the corners and with no soft streaks. We are regularly hardening these bars on a production basis with the setup shown in Fig. 9.

This shows the flame-hardening machine in operation on a 16-in. width surface of one of these bars. When these bars were being planned a $^1/_8$ in. by 45° chamfer was planned on each corner. When the bars are being flame hardened they are partially immersed in water. The water level is brought up to within $^1/_8$ in., that is, right to the bottom of the chamfer. The water level is maintained at this height in order to conduct the heat away from the outer corners so that it will not run through to the adjacent surfaces. This prevents getting a hard area along the edge of the adjacent surfaces. This would cause the corners to crack when the next operation of hardening the adjacent surface is performed. With the water level maintained at this height the hardness will run out about the middle of the chamfer. The two side surfaces of the bar are hardened first, and then the bar is turned over on edge and the two narrow sides are hardened. The setup for hardening the narrow surfaces is the same as that for the wide surfaces with the exception that a narrower width of burner is used and the water level is raised to within $^1/_{16}$ in. of the surface to be hardened. This is done to further prevent rehardening or tempering of the previously hardened surface near the edges.

Following this setup carefully, we have very little difficulty in obtaining a hard surface clear out to the chamfer on each edge nor do we have any great difficulty with cracking at the corners. A straight water spray quench is used and the resulting hardness averages Rc-58–60. The depth of penetration obtained is $^1/_8$ in. The distortion of bars hardened in this manner is very small, it seldom being over 0.010 to 0.120.

A comparison of this process with our former process, which was making the bars out of S.A.E.-2315 steel and carburizing and hardening them, will illustrate the savings of the flame-hardening process. With the carburizing process there were 22 machining operations plus 7 additional operations for thermal treatment required to produce one of these bars. Eight operations were eliminated when the flame-hardening process was introduced. These operations were as follows:

1. Renormalize after rough machining.
2. Sand blast.
3. Finish plane.
4. Carburize after semifinish machining.
5. Sand blast after carburizing.
6. Straighten after carburizing.
7. Sand blast after hardening.
8. Straighten after hardening.

The carburizing, straightening and hardening operations had to be done outside our plant, due to the fact that we did not have furnaces or equipment large enough to handle these bigger bars. This entailed additional expense and considerable lost time. As it was necessary for the bars to be brought in and out of our plant two times, they were sent out to be carburized and then returned to have the carburized case machined off of the portions which were desired to be soft for future machining operations. They were then sent out again to be hardened and straightened.

You can readily appreciate what the savings in just the handling and machining operations alone would amount to on the larger size bars. However, that is not the whole story. In addition to the savings in production cost, we also get a much more uniform hardness pattern and much less distortion by flame hardening. The heavier size bars in particular, due to the great mass of metal involved, did not always carburize uniformly as to depth of penetration. The result was that there were frequently areas where the hardness dropped down considerably. Also due to the great mass of metal it was very difficult to quench rapidly enough to obtain full hardness. The hardness rarely ever hit 60 Rockwell C. In addition, the greater amount of distortion, and the great difficulty of straightening within close limits made it necessary to allow considerably more grinding stock on the surfaces. Quite frequently we found that we were actually grinding through the high carbon case on some of the larger bars which could not be straightened accurately.

The part shown in Fig. 11 is another example where flame hardening is very economical. This part, which is a slide for carrying a cam bar on one of our crankshaft lathes, is made of alloy cast iron. The three adjacent top and bottom surfaces must have a hard wear-resisting case on them. The center or web portion of the part must be left soft for drilling and tapping the holes for the cam bars on assembly. The flame-hardening operation on this part requires approximately 1 hr. to set up and about 20 min. to harden each side.

Another good example of the flexibility of flame hardening is shown in Fig. 10. This shows the setup on our universal machine for flame hardening the graphitic steel wear strips with which all LeBlond lathe beds are now equipped. Three surfaces, that is, the two edges and top surface are hardened to a uniform penetration of $^1/_8$ in. The bottom surface is left soft for drilling and tapping the holes necessary to attach the bar to a lathe bed.

The results obtained on flame hardening these graphitic steel wear strips is shown in Fig. 12. Note the uniform penetration on the three surfaces and also the uniform hardness obtained. Also note from the

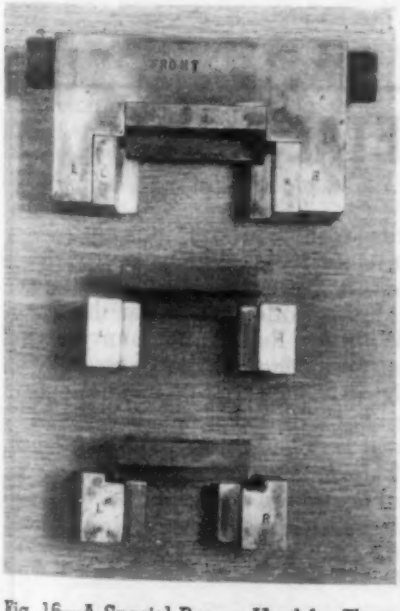

Fig. 16—A Special Burner Used for Flame Hardening the Edges and Top Surfaces of Lathe Bed Wear Strips. Included Are Different Groups of Burner Plates Which Are Interchangeable in the Main Body of the Burner in Order to Accommodate Various Size Bars

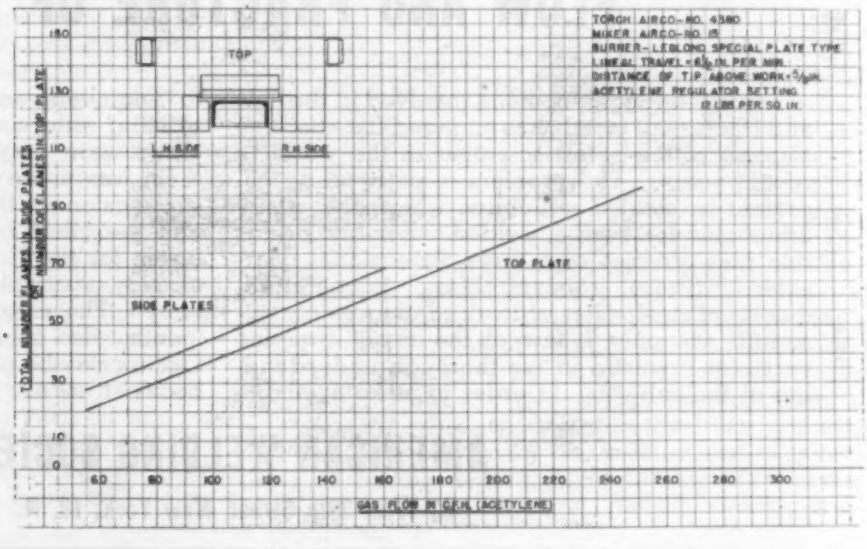
TORCH AIRCO-NO. 4380
MIXER AIRCO-NO. 15
BURNER-LEBLOND SPECIAL PLATE TYPE
LINEAL TRAVEL = 6½ IN. PER MIN.
DISTANCE OF TIP ABOVE WORK = 5/64 IN.
ACETYLENE REGULATOR SETTING
12 LBS PER SQ. IN.
TOP
L.H. SIDE
R.H. SIDE
TOP PLATE
SIDE PLATES
TOTAL NUMBER FLAMES IN SIDE PLATES OR NUMBER OF FLAMES IN TOP PLATE
GAS FLOW IN C.F.H. (ACETYLENE)

Fig. 17—This Chart Gives the Complete Set-Up and Operating Conditions for Flame Hardening Graphitic Steel Bars of the Type Shown in Fig. 12, Using the Burner Shown in Fig. 16

photomicrograph that a fine uniform martensitic structure is obtained with a fairly uniform distribution of graphite nodules throughout. Very little, if any, of the free graphite in the matrix of the steel was reabsorbed into solution during the flame hardening. These bars vary in length from 8 ft. to 15 in.

Figure 13 shows the application of these flame-hardening graphitic steel bars as wear strips on the ways of a LeBlond Heavy Duty Lathe bed.

Another example of the economy of flame hardening is shown in Fig. 14. This large ring gear was used on a large gun-boring lathe built during the war. The gear was finish-machined accurately to size and then the working surfaces of the teeth were progressively flame hardened to give them a hard wear-resisting case. The amount of distortion, if any, was negligible so that the gear could be assembled in the machine after the flame hardening. The individual tooth profile burners used for flame hardening this gear are shown within the gear.

Like any other heat treating or manufacturing process certain tools and fixtures are necessary to perform various operations. Likewise with flame hardening, various sizes and shapes of burners and holding fixtures are necessary for different types of work. Figure 15 shows a representative group of special burners designed for flame hardening various shapes and sizes of small parts.

Figure 16 illustrates the construction of the special burner developed for flame hardening the graphitic steel wear strips which was shown in Fig. 11. There are 9 different cross-section sizes of these wear strips required for our complete line of lathes. They vary in cross sections from $^3/_4$ x $1^3/_8$ in. to $1^3/_4$ x 5 in. For these 9 sizes only two burner bodies are required. Note that this burner is made up of two parts: (1) The main burner body, and (2) the set of burner plates which fit into this burner body as shown in the upper portion of the slide. These removable burner plates are made in sets of three as shown and are of different widths or lengths and have different patterns of flame holes drilled in them to suit the different section sizes of bars. To change from one section size of bar to another it is only necessary to change the three burner plates. The standardized operating conditions for flame hardening these wear strips is shown in Fig. 17. The operator can quickly get the complete setup and operating conditions for any size of bar that comes through from this chart.

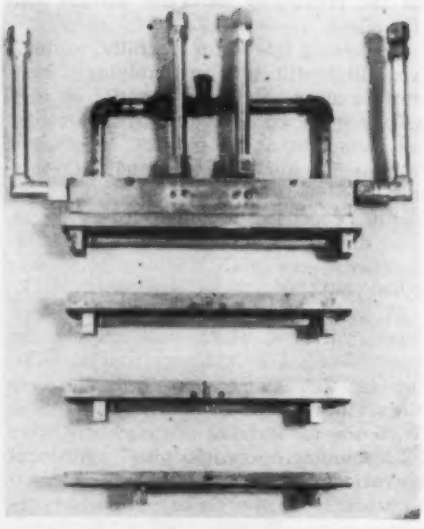

Fig. 18—The Special Burner Body and Various Size Interchangeable Plates Used for Flame Hardening Various Sizes of Tool Bars of the Type Shown in Fig. 8

The construction of the special burner used for flame hardening the 16 in. width of tool bar, shown in Fig. 8 is illustrated in Fig. 18. This burner is also made in two parts, that is, the main body and the removable plate which has the flame orifices and the water orifices built in it. This main body can be used for hardening bars of various widths by changing the removable plate and putting on a plate to suit the width of bar to be hardened. Plates for hardening bars 10, $12^1/_2$ and 14 in. in width are shown and the plate on the burner body is for the 16-in. width.

Conclusion

From these few examples it is easy to realize the value of flame hardening as a heat-treating process to a machine tool manufacturer, or any other manufacturer for that matter. Should his production be intermittent small quantities of numerous different parts or large quantities of a single part, the flexibility of the flame-hardening process would no doubt make it adaptable.

Acknowledgment

The writer wishes to express his appreciation for the very splendid cooperation of The R. K. LeBlond Machine Tool Co. and his co-workers in that organization.

FLOW AND FRACTURE OF METALS

The scientific phenomena involved in the flow and fracture of metals has engaged the attention of some of the ablest scientists in the world in recent years. The problem is particularly important in welded structures where the monolithic character of a welded assembly brings into play stresses of a three-dimensional character. Stress concentrations, temperature, quality of steel, rates of loading, degree of constraint, are only a few of the many complex variables involved in the thorough understanding of the subject. In order to make available to engineers and research workers the best existing information, two comprehensive reviews were prepared on the subject. One of them was made by Major Hollomon under the supervision of the Welding Research Council and the other by Dr. Gensamer and his associates for the U. S. Navy. The first of these is already available in book form at $1.00 per copy. The second will be available within one month, also in book form at $1.00 per copy. Orders may be placed for either or both of these books at once. Address orders to:

AMERICAN WELDING SOCIETY

33 West 39th Street, New York, 18, N. Y.

Welding Techniques for Cast Iron*

By T. E. Kihlgren†

Introduction

THERE are various mechanical methods and fusion welding and brazing processes which may be used to reclaim defective castings or to repair cast-iron parts which have failed in service. No doubt there are instances where one specific method or process is peculiarly fitted to meet the requirements, and there are unquestionably many occasions when the fields of applicability of the various methods overlap or even coincide.

No attempt will be made to evaluate these various methods of salvage or repair. It is proposed rather to confine our discussion of techniques for welding cast iron to those techniques developed and found useful in conjunction with arc welding, using nonferrous electrodes of the nickel or nickel-copper type. Field and laboratory experiences discussed herein are based primarily on arc welding using nickel electrodes.

Purpose of Arc Welding

There are broadly three main categories into which arc welding of cast iron may fall: (1) salvaging of defective castings in the foundry, (2) maintenance and repair welding and (3) fabrication welding.

The contribution made by the welding industry to the gray iron foundry has been one of constantly growing importance, and, today, salvage of defective castings by welding is widely and successfully practiced. The increasing publicity being given by the foundry industry to welding as a production aid will not only result in more widespread application of cast-iron welding, but should also aid in preventing its misapplication.

Maintenance and repair welding of cast-iron parts which have failed in service has been practiced for many years using brazing, oxyacetylene or metallic arc processes. The trend in the last several years has been toward increasing application of arc welding, a trend accelerated by the war and by improvements in available electrodes.

Fabrication welding of cast iron is at a somewhat embryonic stage and its potentialities have yet to be realized. The component parts of the weldment may consist of cast iron only, or of castings and forgings or wrought parts of other compatible metals. In some instances, casting difficulties inherent in a casting design may be overcome by using a weldment of two or more castings. Welding may also be used to join cast iron to other metals, involving such operations as the attaching of steel brackets or fittings to gray iron castings. It is obvious that some caution should be exercised in this third phase of welding, since there is a relatively small background of experience upon which the welding engineer can draw.

Fig. 1—Laboratory Extrusion Press Used in Development of Electrodes

It is proposed in the following discussion to present a few techniques which have been found useful at the laboratory and in the field. A few examples will also be given of each of the three categories into which we have arbitrarily classified welding of cast iron.

Welding with Nonferrous Electrodes

Although arc welding of cast iron is done with both ferrous and nonferrous electrodes, the latter possess the advantage of producing machinable welds even when no preheat is used. While by far the largest portion of arc welding with nonferrous electrodes is done without preheat, there are circumstances under which a moderate amount of preheat is either helpful or advisable.

The use of nickel-copper electrodes for producing machinable welds on cast iron has been practiced for at least about 30 yrs. During this period, improvements were made in the flux coating to yield electrodes which possessed good arc and slag characteristics and deposited welds quite satisfactory with respect to weld porosity considerations. The nickel-copper type of electrode is used in considerable quantities both here and abroad.

Observations at the laboratory, made over a number of years, had indicated commercially available nickel electrodes to have technical advantages over nickel-copper electrodes, particularly with respect to weld hot cracking tendencies. However, these nickel electrodes had not been designed expressly for cast-iron welding, and attention was directed toward the development of a nickel electrode having suitable arc and slag characteristics when applied to cast iron, and operable on either a.-c. or d.-c. current.

Such an electrode was developed as a result of the laboratory studies and ultimately put into production. In connection with this work, a small laboratory extrusion

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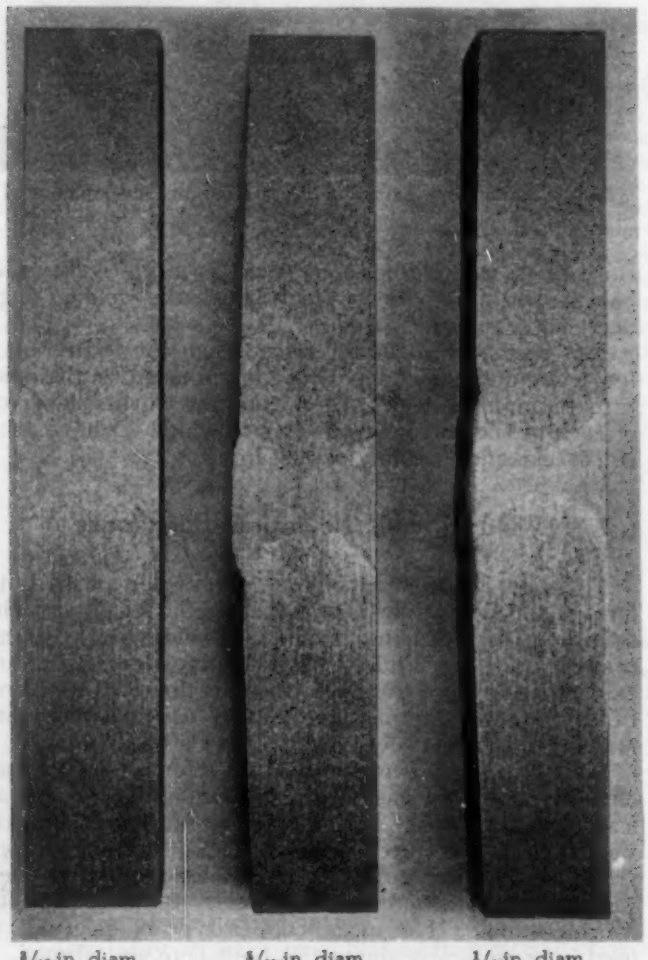
* Presented before A.W.S., New Jersey Section, at Newark, N. J., on May 20, 1947.

† Metallurgist, The International Nickel Co., Inc., Research Lab., Bayonne, N. J.

press was used for preparation of moderate quantities of experimental flux-coated electrodes. As a matter of general interest, the extrusion machine, which was designed and built at the laboratory, is shown in Fig. 1. It permits preparation of modest quantities of electrode ranging from 0.075 to 3/16 in. in diameter. The flux-coating thickness for a given diameter can also be varied over a fairly wide range.

The nickel electrode which was thus developed and upon which most of the welding techniques to be discussed were based can be briefly described. It consists simply of a nickel core wire coated with a carboniferous lime-base flux containing a moderate amount of metallic reducing agents. Sufficient carbon is introduced through the flux coating to obtain graphitic carbon in considerable amounts in the fusion, resulting in improved solidification characteristics as well as a structure imparting a degree of machinability similar to that of the cast iron.

As is well known, there are a number of nickel electrodes now commercially available. Many of the observations made and techniques discussed in the balance of this discussion will be applicable to them as well as to



3/16-in. diam. electrode | 5/32-in. diam. electrode | 1/8-in. diam. electrode

Fig. 2—Machined Cross Sections of Welds on 1-In. Plate Made Without Preheat

the various nickel-copper electrodes. However, whatever nonferrous electrode is used should be employed according to the manufacturer's instructions, which should indicate the optimum condition of operation for that particular electrode.

Influence of Welding Technique on Machinability

While the degree of machinability will vary somewhat

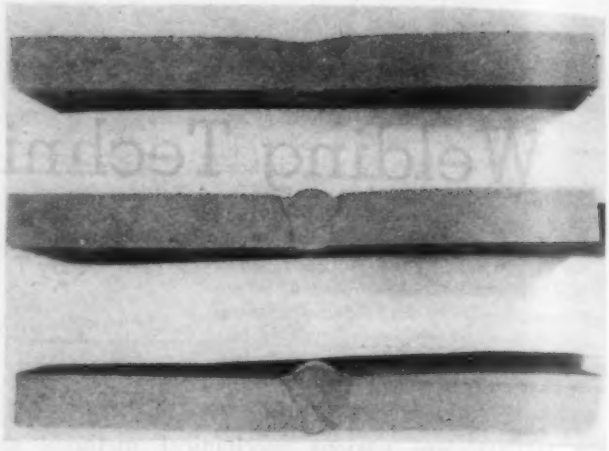


Fig. 3—Machined Cross Sections of Welds on 1/2-In. Cast-Iron Plate Showing Annealing Effect of Cover Passes

with the hardness and structure of the deposit, any weld made on cast iron using nonferrous electrodes is machinable as far as the weld deposit itself is concerned. The condition of the cast iron in the heat-affected zone and at the fusion line, therefore, determines the machinability of the welded joint. The structure of the cast iron in these areas is primarily determined by the composition of the cast iron and by the cooling rate following welding.

Figure 2 shows the machined cross sections of welds made on 1-in. thick cast-iron plate without preheat using 3/16-, 5/32-, and 1/8-in. electrodes. The cuts were made in a shaper at 33 strokes per minute, 0.020 in. feed and 0.015 in. depth of cut. The effect of the superimposed passes in tempering the heat-affected zone adjacent to previous beads may be observed from the figure, the center of the joint showing practical absence of a hard zone. The annealing effect of superimposed passes can be employed to reduce or eliminate hard zones in the cast iron adjacent to the weld, at the surface of the casting. This can be done simply by completing the joint flush to the surface, cooling to about 70–200° F. and then using cover passes, confined entirely to the weld, to reheat and temper the heat-affected zone. Figure 3 shows the effect of such a procedure. The top plate has not been subject to the "cover pass" tempering bead technique while the two below were so treated, the second with a single and the third with a double cover bead. This technique is recommended by several manufacturers of nonferrous welding electrodes.

Occasionally it is necessary to repair surface defects on raised areas such as bosses which must subsequently be machined. Sometimes the mistake is made of merely chipping the defects, welding, and then machining back to the desired level. It is preferable to prepare the area for repair by machining to a little below the desired final dimension, and then building up the surface and machining to the desired level. By such a procedure, all machining is completely confined to the weld deposit. Figure 4 schematically shows "wrong" and "right" methods of building up boss sections.

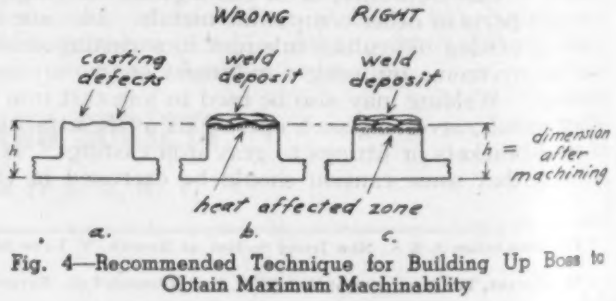


Fig. 4—Recommended Technique for Building Up Boss to Obtain Maximum Machinability

Fig. 5—Method Used by Mold Manufacturer to "Lock" Weld Repair

Preheating and Postheating

In some instances, where machining requirements are especially severe, the use of a preheat may occasionally be indicated, a preheat of as much as 450–600° F. sometimes being employed. A preheat may be particularly useful on a light section not lending itself well to the "cover" or annealing pass technique. It should not be overlooked that postannealing may occasionally be usefully applied. A postheat sufficient to temper martensite may be helpful in reducing the hardness of the heat-affected zone and thus increasing the ability to resist service stresses. This is not common practice, but probably merits consideration where conditions warrant. Postheating may be accomplished with a torch if necessary.

Methods of Making Mold Repair

While acceptable repairs can be made on mold surfaces (glass molds, for example) by conventional methods of chipping and welding, one mold manufacturer uses a more effective method which is depicted in Fig. 5. The center figure shows the defect undercut by chipping prior to welding, and the right-hand figure shows the completed repair. With this method, the deposit is "locked in," minimizing danger of the deposit spalling due to failure in the heat-affected zone of the cast iron.

Degassing of Castings

Occasionally, castings are encountered which contain dissolved gas. While such castings may be perfectly satisfactory from a service viewpoint, attempts to repair such castings by welding lead to weld porosity, due to release of the gas. This difficulty can be overcome by prior subjection of the casting to a simple degassing treatment. The treatment consists of torch heating the *immediate area* against which metal is to be deposited to a dull red, holding briefly and allowing to cool. Figure 6 demonstrates the efficacy of the degassing treatment. Both butt joints were made on the same iron (in this instance a "bath tub" iron of the analysis: 3.40 TC, 2.40 Si, 0.65 Mn, 0.75 P, 0.12 S). The joint on the left was made without prior treatment of the iron, and that on the right after degassing.

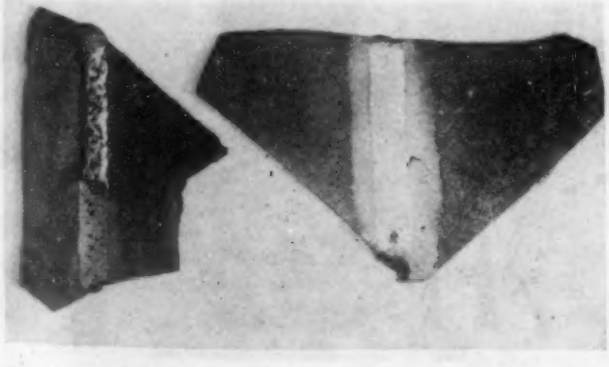


Fig. 6—Effect of Torch Degassing Treatment Applied to High Gas Content Cast Iron, Prior to Welding

Where casting dimensions permit, degasification of the entire casting can be accomplished by furnace annealing at 1000–1050° F. for 15 to 30 min., the time depending upon the section size and the condition of the casting. Temperatures in excess of 1050° F. are undesirable because of the detrimental effect on the structure and properties of the cast iron. Localized torch "degassing" treatments, confined to the immediate area against which weld metal is to be deposited, are less critical in this respect, since the area affected is relatively small, and for the most part, is reheated in the subsequent welding operation to above the transformation temperature.

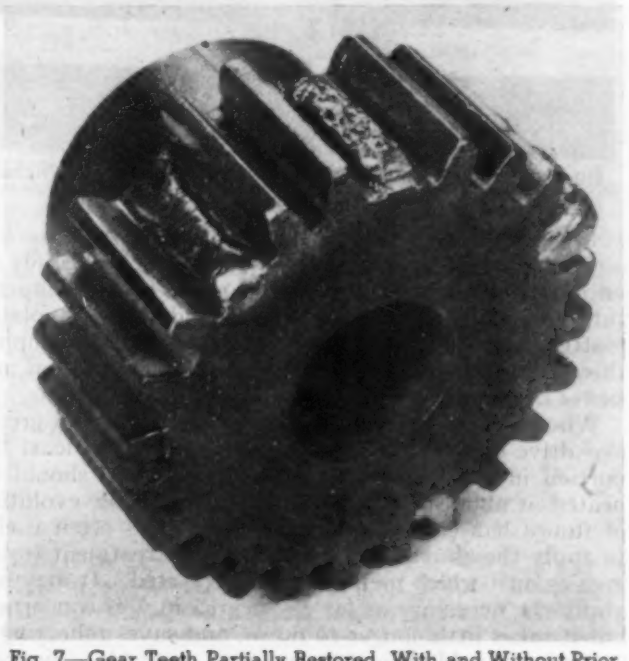


Fig. 7—Gear Teeth Partially Restored, With and Without Prior Degreasing and Degassing

Generally, it is probably preferable, for this reason, to use the torch treatment instead of furnace degassing.

In cases where no pretreatment of the iron is possible, where suitable facilities are not available, or where the requirements are not strict, the first passes can be used to drive off the gas in the vicinity of the weld, the bead chipped and welding continued. This is a less satisfactory procedure than torch degassing, but circumstances may make it acceptable.

It should, of course, be recognized that degassing treatments are not needed in a majority of salvage and repair welding applications. However, the above procedure should be found effective in overcoming such difficulties when encountered.

Oil Impregnated Castings

Castings which have failed in service, in some cases, will have been used under conditions causing them to be saturated with oil and grease, which must be removed before any satisfactory welding can be accomplished. The use of a suitable solvent such as carbon tetrachloride, sometimes in conjunction with cleaning by steam, may often be sufficient where the penetration is superficial.

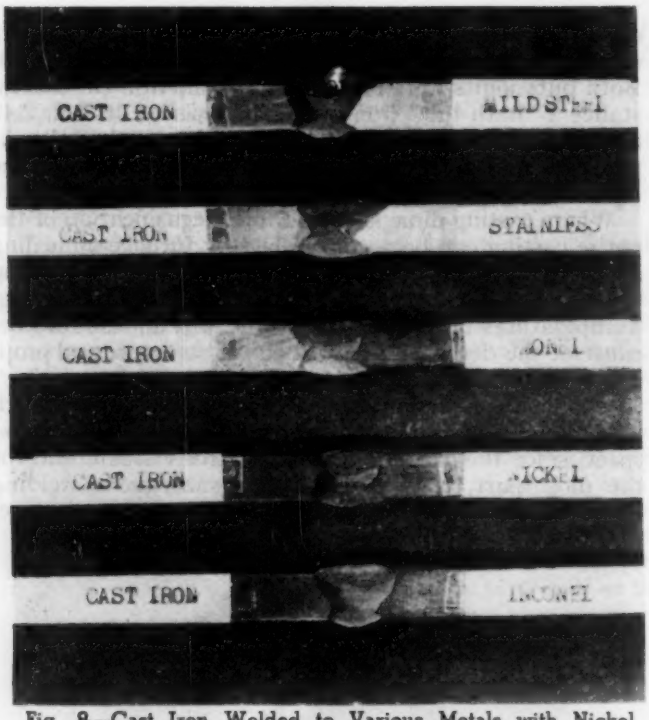


Fig. 8—Cast Iron Welded to Various Metals with Nickel Electrode

In some instances, particularly where the cast iron has a rather open structure, the casting may be so heavily oil impregnated that it is necessary to heat it at a temperature sufficiently high to char the oil and drive off volatile matter. A temperature of about 750° F., will accomplish this, the time required depending on the condition and size of the casting.

When a torch is used to decompose the oil and grease and drive off volatile matter, the casting or at least the portion in the general vicinity of the weld, should be heated at about 750° F., and held until visible evolution of fumes has ceased. At this stage, it is often useful to apply the above described degassing treatment to the area against which metal is to be deposited. It may not always be necessary as far as "degreasing" is concerned, but it takes little longer to do so, and saves reheating if degassing should ultimately be found desirable. Figure 7 shows a gear, one tooth of which was partially restored without preliminary treatment. The other partially rebuilt tooth was welded after driving off oil from the casting and degassing.

Fig. 11—Pump Casing Bosses Originally Supplied Hollow. Arc Welded Without Preheat

Welding of Cast Iron to Other Metals

There have been a number of applications in the field where the welding of steel to cast iron using nickel electrodes has been very successfully accomplished. Occasionally it may also be necessary to join cast iron to other metals. In order to get some idea of the possibilities using nickel electrodes, the following single-vee 60° included angle butt joints were made on $^3/_8$-in. thick plates:

No.	Plate	Electrode	Plate
1	Cast iron	Nickel	Mild steel
2	Cast iron	Nickel	18–8 stainless
3	Cast iron	Nickel	Monel
4	Cast iron	Nickel	Nickel
5	Cast iron	Nickel	Inconel

No difficulty was encountered in securing a good bond in all cases. A Vickers hardness survey (50 kg. load, two-thirds objective) showed the following:

	Plate	Weld	Plate
1	175	171	138
2	181	162	168
3	179	160	146
4	176	173	133
5	177	183	166

The above joints are illustrated in the composite photograph of Fig. 8.

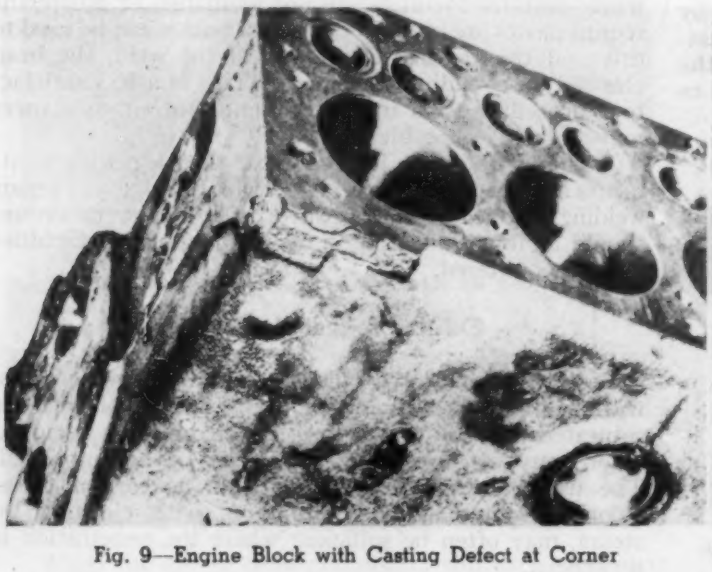


Fig. 9—Engine Block with Casting Defect at Corner

Fig. 10—Engine Block After Repair Welding with Metallic Arc Without Preheat

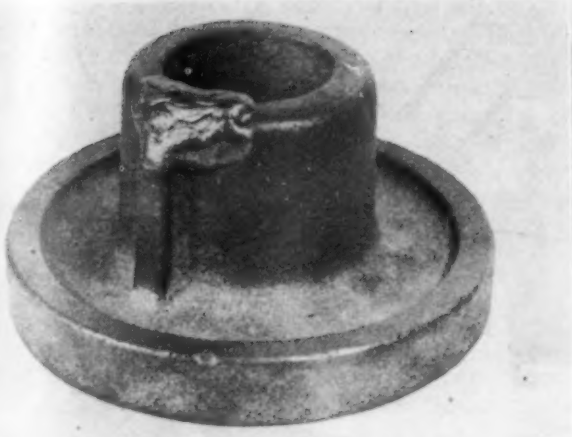


Fig. 12—Defective Casting Reclaimed by Welding—As-Welded

Fig. 13—Defective Casting, Salvaged by Welding, After Machining and Hand Filing to Original Contour

Salvage Welding in the Iron Foundry

Welding is an invaluable tool in the foundry. Defects due to misruns, sand wash, cold shuts, external shrinks, pattern errors, etc., often can be satisfactorily corrected. Judgment must be exercised as to the feasibility of reclamation and whether or not it is economically justified. Such factors as size, shape and initial cost of the castings, and the magnitude, nature and location of the defects enter into the decision on whether to scrap or to attempt salvage.

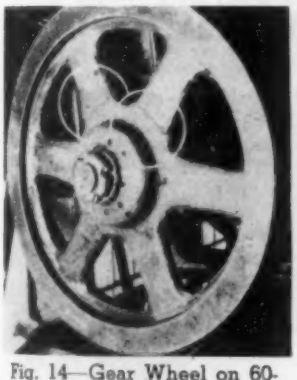


Fig. 14—Gear Wheel on 60-Ton Press Preheat 350–400° F.

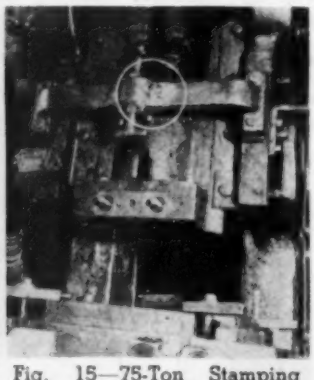


Fig. 15—75-Ton Stamping Press Yoke Preheat 350–400° F.

Fig. 16—Lamp Post Damaged by Collision

Fig. 17—Lamp Post Salvaged by Arc Welding with Nickel Electrodes

Figure 9 shows an engine block, partially machined which contained a defect in the corner. Figure 10 shows the same area after arc welding without preheat, welding intermittently in order to keep the block temperature as low as possible. This is important in a repair of this type, especially when made after partial machining, as excessive heat input may cause distortion and get the cylinder bore out of round.

Figure 11 shows a pump casing which was originally supplied with hollow bosses. Patches were welded into the openings as shown to close up the bosses, correcting the pattern error. No preheat was used.

Figure 12 shows a small casting containing a defect which was chipped and repair welded. The casting was subsequently machined and hand filed to restore the original contour (Fig. 13).

Maintenance and Repair Welding

This is the most common and oldest field of application of nonferrous electrodes. Speed of repair is often of paramount importance and arc welding may then be the only feasible method. Massive equipment can usually be repaired by arc welding with nonferrous electrodes

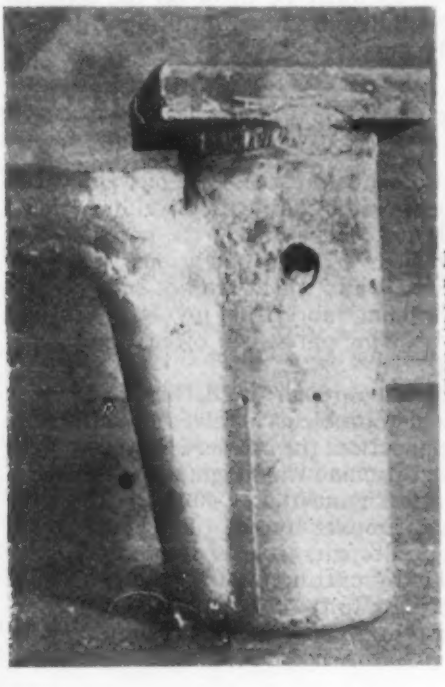


Fig. 18—Compression Chamber of Pressure Die Casting Machine Repaired by Welding Steel Top to Cast-Iron Cylinder with Nickel Electrodes

Fig. 19—Fabricated Aerodyne Fan with Cast-Iron Vanes Arc Welded to Inner and Outer Rings of Heavy Gage Steel Sheet

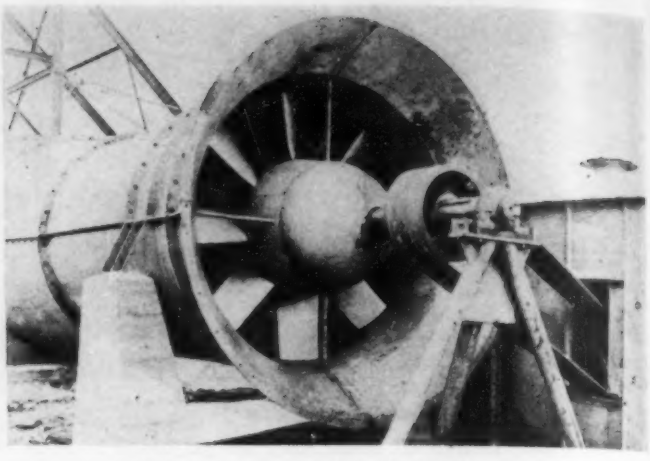


Fig. 20—Fan Installed in Air Shaft of Mine

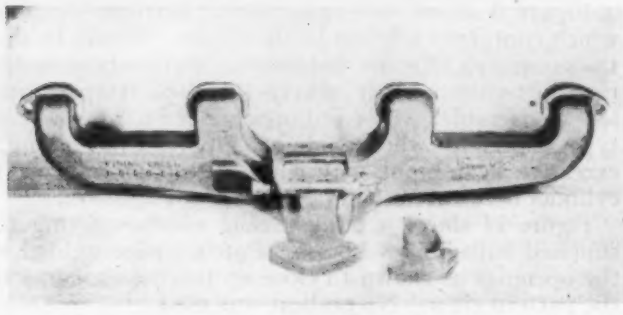


Fig. 21—Manifold Before Attaching Secondary Port Seen in Foreground

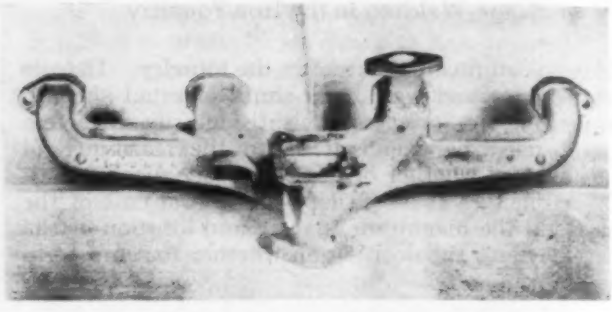


Fig. 22—Manifold Showing Secondary Port Welded to Casting

without the need for dismantling, thus saving several days of labor. Figure 14 shows a fly-wheel on a 60-ton press and Fig. 15 a 75-ton stamping press bracket or yoke, both welded with nickel electrodes. A 350–400° F. preheat applied to the general vicinity of the area to be welded was used in both repairs.

Figures 16 and 17 show a novel application of arc welding. Figure 16 is a photograph of a lamppost after a collision which fractured the base. Figure 17 shows a similar type of post after salvaging. A repair of this type could quite satisfactorily be made on the spot, by use of portable arc-welding machine, resulting in further savings of time and money.

Fabrication Welding

As we have mentioned before, this field of welding has not yet been fully explored. Fabrication welding should be undertaken with due recognition of the nature of the material being welded. Under conditions involving moderate sections and joints which are not subjected to excessive retraint, welding fabrication involving castings only, or cast and wrought parts, can often be satisfactorily accomplished.

Figure 18 illustrates a repair weld, but one which nevertheless is typical of problems involved in fabrication welding. In this application, the pressure chamber of the zinc base die casting machine was originally all made of cast iron. Due to misalignment, the cast-iron top fractured when struck in impact by the plunger. After a number of failures and repairs, it was decided to repair the pressure chamber by cutting off the square top and welding a mild steel plate to the cylinder. This joint, involving steel to cast iron, was made successfully with nickel electrodes.

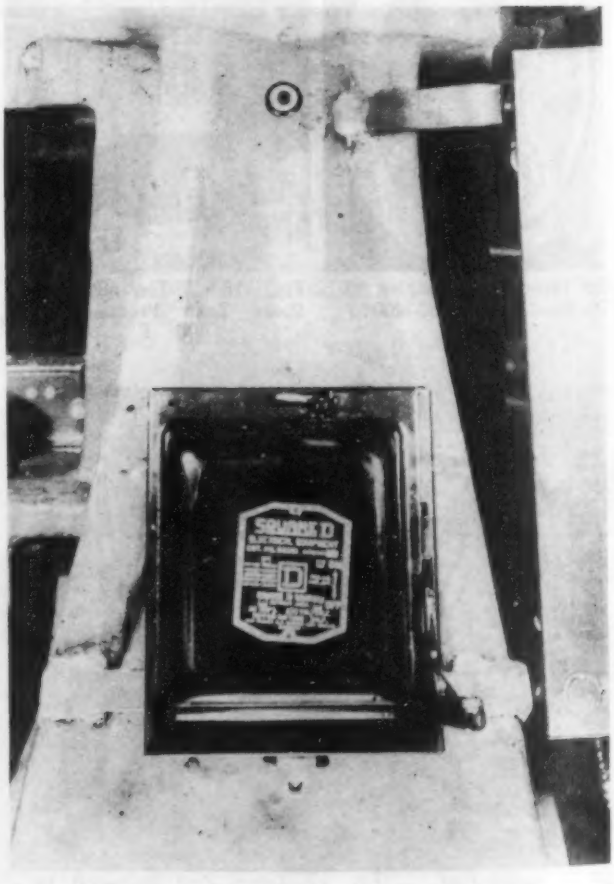


Fig. 23—Showing Method of Attaching Switch Box Supporting Bars of Mild Steel to Cast-Iron Base

Figure 19 shows a fabricated aerodyne fan with cast-iron vanes arc welded to inner and outer rings of heavy gage steel sheet. Figure 20 shows such a fan installed in the air shaft of a mine. The previous procedure on this job involved the drilling of 60 holes in the vanes, the cutting to size of 60 pieces of steel, the drilling of 120 holes in the steel strips and the setting of 60 rivets. One bead was deposited around each corner of each vane, without the use of preheat.

Figure 21 depicts a cast-iron automotive manifold, as purchased from a foundry. The company concerned wish to cut a hole in the manifold and attach a secondary port to it. The separate casting used for the latter port is shown in the foreground. Figure 22 is a photograph of the casting after the welding had been completed. The fabricator indicated the following procedure: inspection of parts, preheat of manifold to 450° F., port set in fixture and mounted on manifold, tack welding of port in three places, removal of fixture followed by continuous welding, and lastly, a postheat to 450° F., removal of slag and air cooling.

An a.-c. welder was used with a reported welding current of 160 amp., using $^5/_{32}$-in. diameter electrodes. The position of the port was maintained accurately at a $3^1/_2°$ angle, $\pm^1/_2°$ and all other dimensions were held within ± 0.003 in. Boring of the port was easily accomplished.

Figure 23 illustrates an application of welding of steel to cast iron, the steel supporting bars on which the switch box is mounted being arc welded to the cast-iron base of the stock turret. Formerly the bars were bolted to the base, installation of the box involving chipping of the casting at four positions, and drilling and tapping of bolt holes. The present procedure consists of single pass welds, using $^5/_{32}$-in. electrodes, without preheat. The electrode is also used to build up the surface where the top bar is attached, in order to bring both supporting bars into the same vertical plane.

These illustrations of fabrication welding should serve to indicate possibilities that exist in this relatively unexplored field, where attractive savings in time and labor often can be made. Again, however, it is well to emphasize that such applications should be approached with due respect for the characteristics of cast iron, and the results of initial fabrication attempts should be checked with some care.

In closing, it is recognized that arc welding with nonferrous electrodes is merely one phase of fusion welding of cast iron, and a discussion of welding techniques for cast iron should properly include all the commonly employed methods. It is also apparent that there is much more yet to be said with respect to techniques of cast-iron welding, even when confined to nonferrous electrodes. However, it is hoped that this discussion will have served to stimulate further interest and bring out new ideas in this important field of application of welding.

High-Speed Oxyacetylene Tube Welding*

By H. O. Jones†

DURING the early stages in the development of the Oxyacetylene Process, the fabrication of tubing was seriously considered. Early in 1908, Davis Bournville conducted experiments on this process for the manufacture of tubing. Our early experience indicated that this process could be used providing suitable forming equipment could be designed for continuous operation. The Davis Bournville Co. was quite active in this early development and after this company was taken over by the Air Reduction Co., these experiments were carried on by a number of successful installations resulting from these early experiments. A considerable number of those original units have been sold in this country and installations have also been made in Belgium, France and Czechoslovakia. The more modern units have been used for a number of years in the production of light wall tubing with wall thickness varying from 10 to 20 gage. By far the largest amount of tubing produced at present is in the light wall conduit field with sizes ranging from $^1/_2$ to 2 in. We have a number of such units operating at speeds of from 100 to 140 ft. per minute. Our latest machine was developed for one of the larger refrigerator manufacturers for the production of condenser tubing. This unit is a continuous type, operating from a continuous feed through a looping arrangement whereby operations can be carried on without interruption. This is accomplished by butt welding the trailing end of one coil to the leading end of the next. This strip is then fed into a looping arrangement having approximately 300 ft. of skelp as a working reserve. In this operation the end of the coil is stopped upon reaching the clamps provided, where it is sheared to square the ends and the next roll is joined to this by the butt-welding operation. While this is being accomplished, the material from the looping arrangement is being fed into the machine. As soon as the weld is made, the operator releases the holding clamps and the looping arrangement is brought back to its original position so that we continue to have 300 ft. of skelp as a constant reserve.

In the forming operations we pass through four vertical stands and two inter-conductor rolls. The final form of the tube, prior to entering the welding rolls, is of a "U" shape. This form is held through seven conductor rolls with the oxyacetylene flames impinging upon the upturned edges. By this ingenious method, we can accomplish much higher speed with a marked saving in oxygen and acetylene consumption. The areas heated by this process are a fairly narrow band ranging back approximately $^1/_{32}$ in. from the edge of the skelp. In the final welding rolls, this skelp is brought over the edges

* Presented at the Twenty-Eighth Annual Meeting, A.W.S., Chicago, Ill., week of Oct. 19, 1947.

† Technical Sales Division, Air Reduction Sales Co., New York, N. Y.

brought together by the final welding roll. In this welding roll we accomplish two things: we butt the edges under pressure and roll down what would normally be the flash on the outside of the tube.

The tips themselves are made in several sections and their length depends upon the maximum speed required. Each tip section has its own torch and mixer and the gases are individually controlled from the operator's position. The number and diameter of the holes in each tip section depend upon the maximum speed required. They may vary in number from 24 to 52. Each tip section is individually water-cooled together with the torch and mixer so as to maintain a constant temperature throughout the tip. The tips are arranged in multiple sections and for the high-speed units may have as high as four individual sections. The leading or preheat sections carry a highly oxidizing flame for a very rapid preheat, having a gas ratio of one volume of acetylene to 1.8 volumes of oxygen. This gas ratio is gradually reduced until we reach the final section which carries a neutral flame, having a gas ratio of one volume of acetylene to 1.2 volumes of oxygen. By this method of heating, we are able to use the highly oxidizing flame for rapid preheat and the purely neutral flame for the actual welding operations. In this final area we are working at a neutral or just slightly reducing atmosphere which is ideal for these welding operations.

After leaving the welding roll, the strip passes into a cooling tube and is cooled to room temperature. From there it passes into a rotary straightener whose head is travelling at 4500 r.p.m. This head is equipped with a number of dies which rotate around the tube, each die in turn exerting a slight amount of pressure so as to straighten the tube in all planes. It then passes into two pairs of sizing rolls which size the tube to commercial specifications. The tube then enters the cut-off unit and is cut to the proper length for condenser tubing.

This machine has been in operation for quite some time and is operating on a production basis of 204 ft. per minute. The total acetylene consumption is approximately 400 cu. ft. per hour with oxygen consumption at 550 ft. per hour. It requires two men to operate the unit as the finished tubing is conveyed directly from the cut-off machine to the next operation which is swedging each end for insertion into the condenser header. The tubing produced on this unit is $^1/_4$ in. O.D. with 0.019 wall and $^3/_8$-in. O.D. tubing having a wall of 0.023. Our experiments show that speeds of from 200 to 250 ft. per minute are entirely possible in this light wall tubing.

Our modern design of tube mills, involving basically the same principle as outlined but having improved features such as precision regulators, are controlled through a pilot circuit from the control board adjacent to the operator. The unit itself is driven through a hydraulic drive so that we have infinite steps in speed control from minimum to maximum, this control being located adjacent to the operator and readily accessible for adjustment. Individual torch hangers are provided so that each individual torch may be adjusted to suit the welding conditions. Each individual vertical roll is adjustable from the front of the welding unit, thereby cutting down the normal set-up time and allowing the operator to make these adjustments while the unit is in operation.

The forming section will have six or more vertical stands, depending upon the wall and the size of the tubing. The upper and lower rolls are driven through speed reducers and both the upper and lower rolls are adjustable, having micrometer readings so that they may be preset and adjusted to compensate for roll wear. The total adjustment on both the upper and lower rolls is 3 in. total. Each roll is driven independently through a universal joint and a spline shaft to compensate for roll adjustment. Each stand is equipped with shear pins so that no damage will result to the driving mechanism. By these features we can greatly reduce the time involved for changing rolls when it is necessary to change tube diameters.

In the production of light wall conduit we find that a number of manufacturers are able to use hot-rolled, unpickled strip to a decided advantage. First of all, the cost of the hot-rolled strip is approximately $3.00 per ton less than cold-rolled strip and the presence of scale in the hot-rolled strip does not interfere with the welding operations. However, we do find somewhat greater roll wear when using hot-rolled strip due to the abrasion qualities of the scale but we find that this roll wear is less costly than the increased cost of cold-rolled material. The tubing is cut to 20-ft. lengths and is either pickled or galvanized. By being able to use cheaper material, considerable savings in the production of the tubing are effected by using this process.

In July of this year we moved to our new laboratory located at Summit, N. J. In this new laboratory we have more than tripled our shop area and have added additional equipment for further research to determine the maximum speeds possible by this oxyacetylene process. At the preset time, we have a mill which we have assembled on our floor on which we are conducting additional experiments involving greater economy and higher speeds. Theoretically, the speeds are unlimited by this process due to the fact that we are not limited by the length of the welding section nor the amount of heat which can be utilized by this process. I believe we can safely say that the present speed of oxyacetylene-welded tubing will at least be doubled within the very near future.

At the present time experiments are going on with many different types of tips and various gases which will give us better weld characteristics and better finished tube.

SURVEY OF AUTOMATIC

require rather precise operating conditions; therefore the detailed procedure to be used for any given application should be carefully worked out

SURVEY OF AUTOMATIC ARC AND GAS WELDING PROCESSES AS USED IN THE AUTOMOTIVE INDUSTRY

A Committee Report

* NOTE: This report has not received final approval as yet. It is being published in THE WELDING JOURNAL for the purpose of securing comments, criticisms and suggestions.

To be considered, these should be addressed to S. A. Greenberg, Secretary, Automotive Welding Committee, AMERICAN WELDING SOCIETY, 33 W. 39th St., New York 18, N. Y., and should be received not later than MARCH 1, 1948.

FOREWORD

IN THE course of the Committee's activities, the members of the AMERICAN WELDING SOCIETY Automotive Welding Committee undertook an exchange of information on the practices in the use of the automatic arc and gas-welding processes in their respective plants. Because of the interest this activity aroused in the Committee, it was decided to publish this Survey and thereby make the data more widely available.

By virtue of its origin, this Survey reflects only the experiences of the automotive plants represented on the Automotive Welding Committee; it may not be entirely comparable with information on the use of these processes for other applications. For this reason, the data contained herein should not be regarded as representing specific recommendations providing optimum conditions for using these processes under all conditions.

However, the Committee in deciding to publish this information has done so in the belief that the experience of its members as reflected in this Survey will be of interest to potential users as an indication of how these processes are being used, and to other present users as a basis for comparison of the use of these processes for different applications in different industries.

Since the Survey represents a consensus of experience, the information it contains is of a broad, general nature. Where numerical data are given, it will be found that broad ranges are specified. These processes generally require rather precise operating conditions; therefore the detailed procedure to be used for any given application should be carefully worked out for that application.

This Survey represents the information available at the time of its issuance. Obviously, it cannot reflect developments in new equipment or in new uses occurring subsequent to that time. However, if sufficient interest is evidenced, the Survey will be reviewed periodically and brought up-to-date.

GENERAL

This Survey contains a brief, general discussion of each of the automatic arc and gas welding processes listed at the end of this section. Included are a description of the basic principles of each of the processes and the general limitations affecting each process. No attempt has been made to discuss these factors in detail, nor have such things as the uniformity of edge preparation, jigs for holding the parts to be welded, electrical conditions to secure uniform current supply been mentioned to any extent. These and other similar factors should be carefully worked out for each separate application.

The data included in this report apply primarily to the welding of butt joints. However, the same general principles apply to the making of fillet welds in lap, tee and corner joints as well as to building up surfaces of parts by welding. The limitations for speed of welding and the backing provisions specified for groove welds in butt joints will vary to some extent for fillet welding.

Automatic welding by any of these processes, is generally employed where repetitive welding operations can be performed on a production basis and low cost welding is important. As an economic matter, consideration is usually given to the number of parts to be welded, to determine whether the extra cost for initial installation of the automatic equipment is warranted. In such an evaluation, due consideration must be given to such factors as preparation for welding as well as cleaning or processing after welding.

Following are the automatic arc and gas welding processes included in this Survey and the order in which they are presented:

1. Submerged Arc Welding.
2. Automatic Shielded Metal-Arc Welding.
3. Automatic Bare Metal-Arc Welding.
4. Automatic Carbon-Arc Welding.
5. Automatic Atomic Hydrogen Welding.
6. Automatic Inert-Gas Shielded Metal-Arc Welding.
7. Automatic Oxy-Acetylene Welding.

1. SUBMERGED ARC WELDING

Submerged Arc Welding is a shielded metal-arc welding process in which the welding is performed in a protecting atmosphere produced by the com-

bustion of a suitable granular material placed so as to submerge the welding arc between the electrode, which supplies the filler metal, and the work.

Figure 1 shows schematically the application of this process to the welding of a butt joint. A V-groove preparation, the dimensions of which are related to the thickness and type of material being welded, is necessary. A granulated fusible type of flux is applied to the work, upon which a bare wire is fed. An arc is established between the bare wire and the parts to be welded. The welding operation is automatically controlled by means of a welding head in which the arc voltage controls the speed of wire feed. The speed of the wire is directly related to the current being used and to the arc voltage that is being maintained.

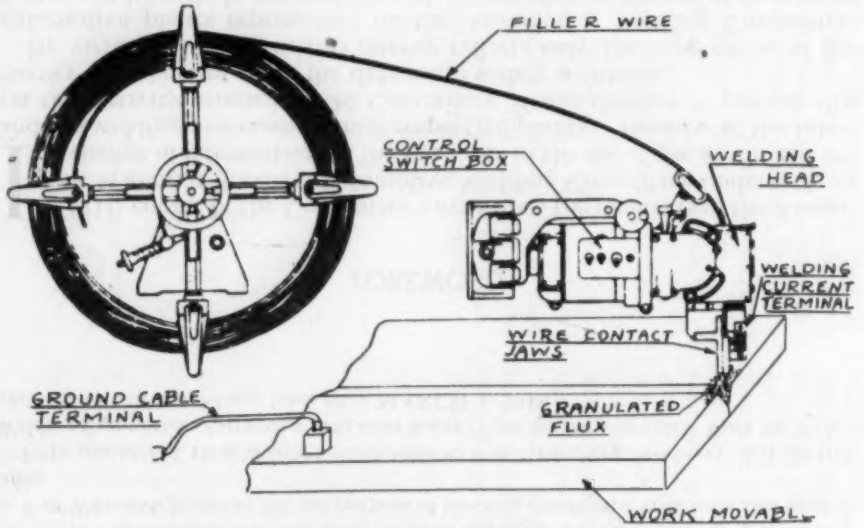


Fig. 1—Submerged Arc Welding Head

Automatic Welding Is Accomplished Either by Mechanical Movement of Head or Work

This process is more usually used for single pass welds, although it is also applied to multilayer welding. On heavy plates, a single pass weld is applied from each side of the plate. In general, automatic welding heads used for bare metal-arc welding can be used for submerged arc welding. The weld metal deposited by this process under proper conditions is of high quality, and complies with accepted standards for radiographic inspection and mechanical properties as specified by the various code requirements.

Flux

The flux for use with this process must be carefully selected and is usually available in a number of different chemical compositions or grades, depending upon the thickness and composition of the material to be welded and the speed of welding. The grinding of the flux is of considerable importance and different screen sizes of each grade of flux are available. The function of the flux is to shield the area surrounding the weld metal against oxidation and contamination from the atmosphere. The flux also serves as an arc stabilizer. Alloying elements can be compounded into the flux to be incorporated into the weld metal during welding.

Electrodes

The electrode is usually copper-plated carbon-steel wire, the chemistry of which varies, depending upon the type of material being welded and the mechanical properties desired. Alloy-steel wire is also available for use with alloy-steel electrodes.

Welding Current

Either alternating current or direct current is used for this process, the choice depending upon the thickness and compositon of the material to be welded. For the thinner gages of mild steel, direct current is usually preferred. One of the characteristics of this process is that high current densities can be used without materially affecting the quality of the weld.

Base Metal Composition

The submerged arc welding process is rapidly being applied to a great variety of alloys, both ferrous and nonferrous. By far, its greatest application has been in welding low-carbon or mild steels. It is also being used to weld high-strength low-alloy steels which are available in plate form. At the present time there seems to be no definite limitations as to the alloy content of the plate material which can be used. With the higher alloy air-hardening types of steel, it is necessary to apply special precautions such as preheat, postheat, etc. The submerged arc process is also used on various types of stainless steels. The straight chromium and the austenitic chromium-nickel alloys are readily welded by this process. Welding of the columbium bearing austenitic type of stainless steels is still in the experimental stage. Among the nonferrous alloys, nickel, Monel, cupro-nickel, Inconel and aluminum have been successfully welded by this process. Experimental work is under way for developing suitable welding procedures for copper-base alloys.

Thickness of Material

For mild steel, the thickness which may be welded varies from $^1/_{16}$ inch to $2^1/_2$ inches for complete penetration welds. The heavier thicknesses are welded with one pass from each side. When the submerged arc process is used for multilayer welding, the thickness is unlimited except by the design of the part being welded. On alloy steels and nonferrous materials, the thickness limitations have not been completely established.

Speed of Welding

The speed of welding mild steel varies from a maximum of 300 in. per minute for 18 gage to 3 to 4 in. per minute for heavy sections. A typical speed current and thickness relationship for a particular groove design is shown in Fig. 2. The speed of welding is influenced by the chemical composition of the flux, the thickness of the material, its composition, and the welding current.

Edge Preparation

The preparation of the groove will depend upon the thicknesses of the

is welded at a lower amperage in order not to penetrate through the root

and the speed of welding. The grinding of the flux is of considerable importance and different screen sizes of each grade of flux are available. The function of the flux is to shield the area surrounding the weld metal against

shown in Fig. 2. The speed of welding is influenced by the chemical composition of the flux, the thickness of the material, its composition, and the welding current.

Edge Preparation

The preparation of the groove will depend upon the thicknesses of the plates being welded and the composition of the material. No special preparations are necessary for mild steel 1/4 inch or less in thickness and the plates can be welded with square edges. For heavier mild steel plates, single-V grooves and double-V grooves are used with root face. Tables of recommended groove design are usually supplied by the manufacturers of the equipment. The preparation of the edges can be accomplished either by machining the surfaces, chipping or by gas cutting. In any case, the edges must be clean and free from rust, oil and foreign material. A thin film of oxide or scale resulting from gas cutting is not objectionable.

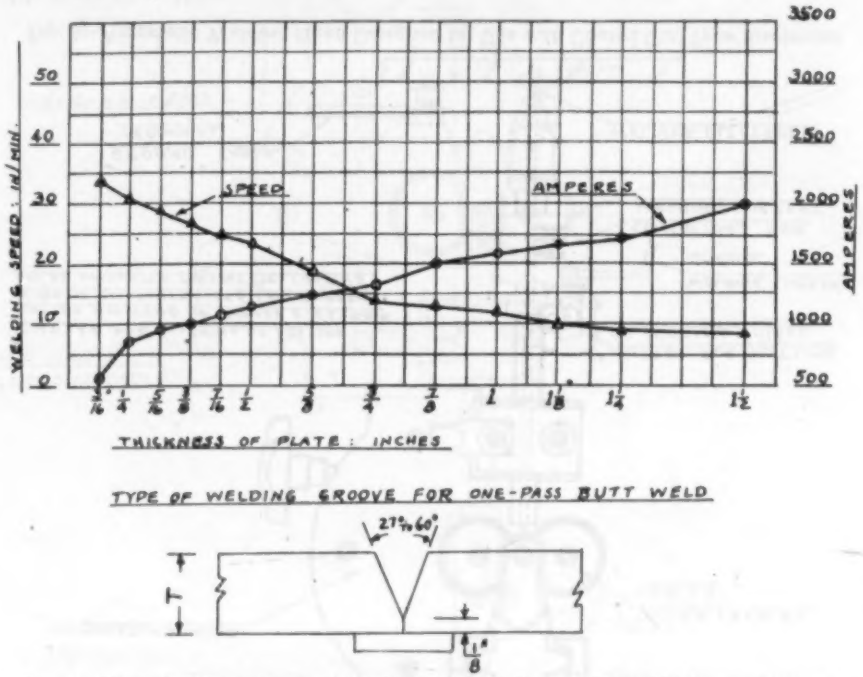


Fig. 2—Typical Relationships of Welding Speed Versus Plate Thickness in Low-Carbon Steel Material for Submerged Arc Welding

Backing Provisions

A number of different methods of backing can be used for submerged arc welding. For thin gages, a copper backing is generally used. The copper backing may be flat or grooved, depending upon the penetration desired. Flux backing is sometimes used when welding is done on one side only, in which case the usual flux or a special compositon flux is used. The flux is usually supported in a groove with some provisions for a flexible backing to hold the flux tightly against the root edges.

For heavy plates, where welding is performed from both sides, a first pass is welded at a lower amperage in order not to penetrate through the root face of the scarfed edges. The second pass from the opposite side is welded with higher amperage to thoroughly fuse with the first pass. Welding by this method makes it mandatory that the edges are fitted fairly tight and that no gap greater than 1/16 inch exists between the abutting edges. Some applications require that one side of a double-groove joint should first be welded manually and then completed by welding with the submerged arc process.

Fit-Up

Fit-up is of prime importance for submerged arc welding. Joint fit-up must be sufficiently accurate so that too wide a root opening is not obtained. The alignment of abutting edges must also be held to close tolerances. If the edges are prepared by gas cutting, the operation must be performed with sufficient care to produce a uniform root face and angle of bevel and to avoid irregularities which would produce gaps in the joint.

2. AUTOMATIC SHIELDED METAL-ARC WELDING

Automatic shielded metal-arc welding is essentially the same as manual shielded metal-arc welding except that means are provided for automatically feeding the covered electrode and for moving the arc along the joint to be welded.

A typical automatic welding head for use of covered coiled electrodes is shown in Fig. 3. Means are provided in the head for cutting slots or slitting the electrode covering by means of cutters, in order that contact can be obtained with the bare core wire for transmitting the welding current. One modification of this process is the use of an impregnated tape which is wire reinforced, and which is wrapped around the core wire in the welding head, during feeding of wire. In this case current is conducted to the bare wire just above the point where the tape is wrapped around the core wire.

Another modification of this process is the use of wire mesh woven around the core wire in which the mesh is filled with a fluxing material. With this type of electrode, the contact is made directly to the core wire through the wire mesh reinforcement by means of roller contacts. A further modification of this process is a stick feeder type of welding head, in which individual straight lengths of coated electrodes are fed through the welding head. In this case, however, contact is made at the bare end of the electrode, which is similar to that used for manual welding.

Various electrical and mechanical devices are in use to regulate the arc length by automatic control of arc voltage. The weld metal deposited by this process is similar in quality to that described under submerged arc welding. However, because of the characteristics of this process the weld metal is usually deposited in thinner layers.

Electrode Covering

In general the function of the covering is to shield the arc from atmospheric contamination, to stabilize the arc and to incorporate alloying elements into the weld metal. Variations in the covering depend upon the type of material being welded. For the high strength alloys, alloying ele-

ments are often incorporated in the covering to provide the necessary tensile strength and other mechanical properties. Some of the coverings are also modified for special applications as for fillet welding or deep groove welding.

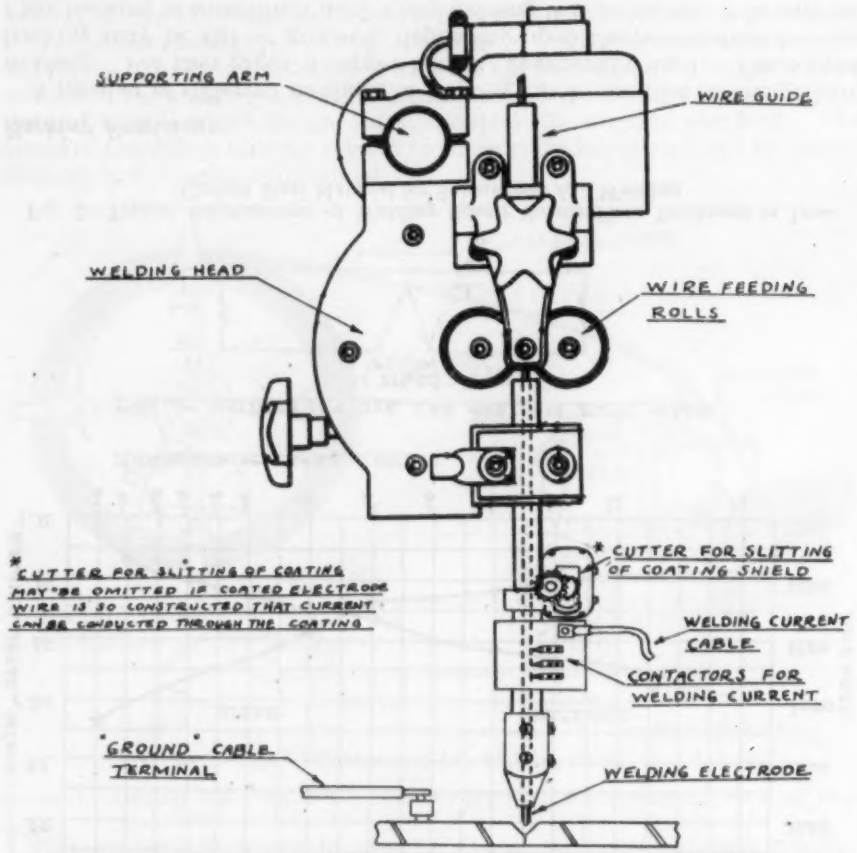

SUPPORTING ARM
WIRE GUIDE
WELDING HEAD
WIRE FEEDING ROLLS
* CUTTER FOR SLITTING OF COATING SHIELD
* CUTTER FOR SLITTING OF COATING MAY BE OMITTED IF COATED ELECTRODE WIRE IS SO CONSTRUCTED THAT CURRENT CAN BE CONDUCTED THROUGH THE COATING
WELDING CURRENT CABLE
CONTACTORS FOR WELDING CURRENT
GROUND CABLE TERMINAL
WELDING ELECTRODE

Fig. 3—Automatic Welding Head Designed for Use with Coated Coil Type Electrodes

Electrode Core Wire

The core wire diameter may vary from $^1/_8$ inch to $^3/_8$ inch, depending on the thickness of material being welded. The most widely used diameters are $^3/_{16}$ inch and $^1/_4$ inch. The composition of the core wire is also modified according to the intended application, similar to the modification described above for electrode coverings.

Welding-Current

The current for automatic shielded metal-arc welding can be either alternating or direct, depending upon whether transformers or direct-current generators are used. With this process, the current density is limited by the composition of the electrode covering. In general, a higher current density is used for the same diameter of electrodes than is used for manual welding. The polarity of the electrode in direct-current welding depends upon the covering composition. Either reverse polarity (electrode positive) or straight polarity (electrode negative) give satisfactory performance.

Base Metal Composition

This process is most widely used for welding low-carbon steels and low-alloy, high-strength steels.

Thickness of Material

The thickness of material may vary from 12 gage to $^3/_8$ inch without edge preparation and to unlimited thicknesses in grooved plates where multiple pass welding is used. Fillet welds in the flat position or horizontal position may be made in single or multiple passes.

Speed of Welding

The speed range for this process may vary from 3 inches to 50 inches per minute, and will depend upon the type of welding groove, the thickness of the material, composition of material and the welding current used.

Edge Preparation

Preparation of the groove for welding by this process is very similar to that used for manual metal-arc welding. On light gages, the edges are square and butted together, while on heavier sections either V-grooves or U-grooves can be employed. The preparation can be accomplished by either machining, chipping or gas cutting.

Backing Provisions

The backing used for this method is similar to that used for manual metal-arc welding. For this purpose low-carbon steel backing straps are employed, and in some cases copper backing, either plain or grooved is provided. The latter is used where full penetration welds are not desired and the copper also acts as a chill bar to prevent metal from dropping through.

Fit-Up

The fit-up is similar to that which is used for manual metal-arc welding. In many cases, however, it must be more uniform because of the automatic welding involved and because of the higher currents and speeds that are employed therefor.

3. AUTOMATIC BARE METAL-ARC WELDING

Automatic bare metal-arc welding is a welding process which employs a bare electrode, automatically fed to the work, and some flux which will stabilize the arc. There is no shielding medium, although the flux may have the effect of shielding incident to its prime purpose of stabilizing the arc. The automatic bare metal-arc welding process is used where low-cost welding and speed are of prime importance. A typical welding head for this process is shown in Fig. 4. In this process a bare wire with a very light flux coating is fed through a nozzle which directs the arc to the work. The arc length is controlled by electrical and mechanical devices and is de-

processes. The weld metal is comparatively brittle, contains fine porosity, and is saturated with oxides and nitrides, as a result of contamination from

generators are used. With this process, the current density is limited by the composition of the electrode covering. In general, a higher current density is used with this process than with shielded manual metal-arc welding.

welding and speed are of prime importance. A typical welding head for this process is shown in Fig. 4. In this process a bare wire with a very light flux coating is fed through a nozzle which directs the arc to the work. The arc length is controlled by electrical and mechanical devices and is dependent upon the arc voltage. In some modifications of this process, the wire is knurled in order that more flux can be incorporated into the wire for stabilizing the arc.

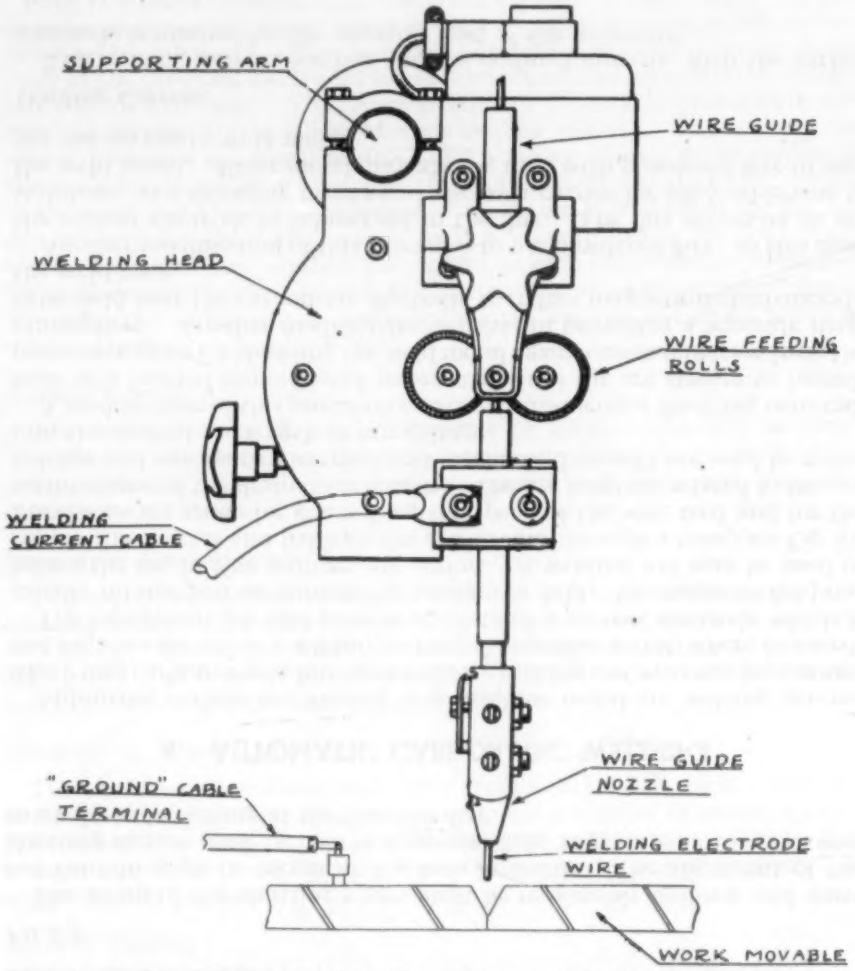


Fig. 4—Automatic Welding Head for Use with Bare and Lightly Coated Electrodes

Automatic bare metal-arc welding is usually limited to single-pass welding; it is rarely used in multilayer welding. In some cases a high frequency unit is super-imposed on the welding circuit in order to eliminate some of the starting difficulties encountered with this process.

Because of inadequate shielding, the quality of the weld metal deposited by this process is not comparable to that obtained by the automatic shielded processes. The weld metal is comparatively brittle, contains fine porosity, and is saturated with oxides and nitrides, as a result of contamination from the atmosphere. In spite of the low quality of the weld metal, the process is commercially important, because of its low cost and satisfactory performance for some types of work.

Flux

The purpose of the flux is primarily to stabilize the arc, although some beneficial action is also obtained by improving the quality of the weld metal. The amount of flux applied to bare wire electrodes is usually very light and is in the form of a film on the surface of the wire. This flux is applied to the wire by different methods, such as dipping, wiping and in the wire drawing operations. In some cases, special grooves or notches are made in the wire to increase the amount of flux adhering to the wire.

Electrodes

Electrodes for automatic bare metal-arc welding are provided in various grades, depending upon the characteristics desired. Wire is furnished in low- and high-carbon ranges, and varies in diameter from $^{3}/_{32}$ inch to $^{1}/_{4}$ inch. The wire is commonly supplied in coils of approximately 50 pounds in weight.

Welding Current

Either alternating or direct current can be used for this process. The current density is usually higher than for shielded manual metal-arc welding. For direct current applications, straight polarity (electrode negative) is generally used.

Base Metal Composition

Automatic bare metal-arc welding is most generally used for low-carbon steel. There are special applications where copper-base alloy wire is used to weld material of the same composition. Some other alloys can be welded by this process; however, such applications are very limited.

Thickness of Material

Automatic bare metal-arc welding is generally used on material of light gages, varying from $^{1}/_{32}$ inch to $^{5}/_{32}$ inch. In some applications involving overlay deposit, heavier sections may be welded.

Speed of Welding

The speed limitation depends upon several factors, such as fit-up, adequate holding fixtures, cleanliness of stock and dimensions and shape of parts welded.

The usual range of speed is from 10 to 60 inches per minute. In some special installations where intermittent or skip welding is used, the welding speed may be increased to 200 inches per minute.

Edge Preparation

The edges should be clean and free from excessive oil, grease, scale, etc. Special edge preparation is not necessary because the material for butt

joints is relatively light, and does not require scarfing. Square edges obtained by shearing, blanking or machining are satisfactory.

Backing Provisions

A backing for high-speed welding is usually necessary to prevent the metal from dropping through, and consists of either a copper or steel support. The backing is usually incorporated in the welding fixtures, and may be water cooled if necessary.

Fit-Up

The fit-up of the abutting edges must be reasonably uniform and must not contain gaps in excess of $^1/_{16}$ inch in width. The alignment of the abutting surface must be held to approximately 10 percent of the thickness to avoid undercutting at the junction line.

4. AUTOMATIC CARBON-ARC WELDING

Automatic carbon-arc welding is a machine metal-arc welding process which uses carbon or graphite electrodes for making and maintaining the arc, and requires the use of a welding rod to provide filler metal, where required.

The equipment for this process consists of a carbon electrode which is usually rotated and surrounded by a magnetic field. The magnetic field stabilizes the arc to give uniform arc action. A welding rod may be used to supply filler metal and fed into the arc stream through a tube (see Fig. 5). Provisions are made for controlling the speed of the wire feed and for the maintenance of the desired arc length. The arc length is related to the arc voltage and automatic electrical and mechanical devices are used to maintain the desired arc length or arc voltage.

A modification of this process consists of introducing a shielding material, such as a twisted impregnated paper strip, into the arc stream to furnish protective gases for shielding the weld metal against contamination from the atmosphere. Another modification consists in providing a separate magnetic field near the carbon-arc electrode to reduce magnetic disturbances in the weld zone.

Another modification of this process is to use powdered flux; in this case, the carbon electrode is submerged in the flux. The flux serves as an arc stabilizer, as a shielding means and also as a carrier for alloy additions to the weld metal. Filler metal may also be used with powdered flux to supply the necessary weld metal.

Welding Current

The welding current for this process is direct current, with the carbon electrode connected to the negative lead of the generator.

Base Metal Composition

Carbon steel ranging from 0.10 percent C or less to 0.40 or 0.50 percent, galvanized steel and other coated steels as well as low-alloy steels can be welded by this process. The automatic carbon-arc welding process is also used to weld nonferrous metals and alloys such as aluminum and aluminum-alloys and copper and copper-alloys.

Thickness of Material

The range of thicknesses for carbon steel extends from 12 gage to $^3/_4$ inch. The thickness limits for other materials have not been definitely established.

Speed of Welding

The welding speed may vary between 3 inches and 50 inches per minute on carbon steel. The speed is related to such factors as fit-up, thickness of material and welding current. For other materials, the speed limits have not been definitely established.

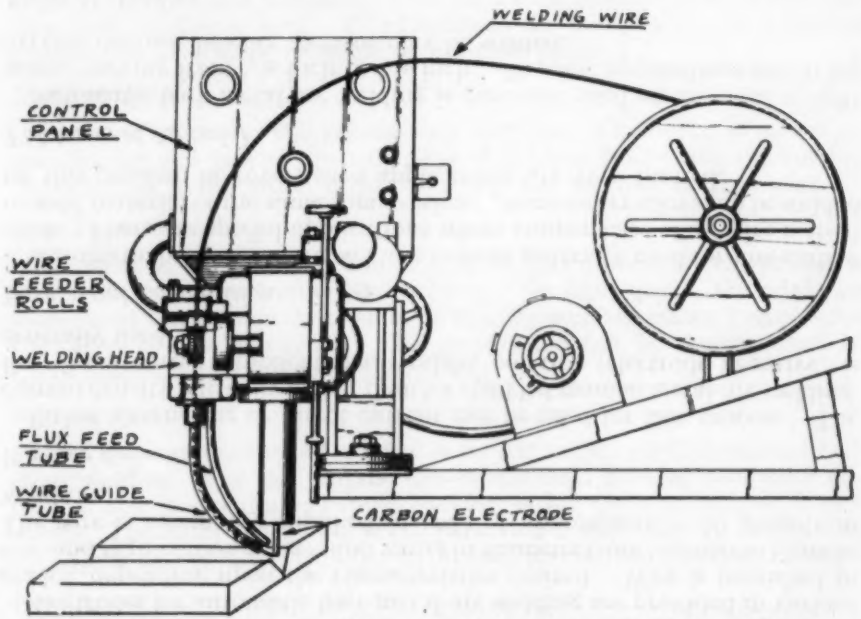


Fig. 5—Automatic Carbon Arc Welder Containing Carbon Electrode and Mechanism for Feeding the Fibrous or Powder Shielding Material as Well as Filler Metal

Edge Preparation

Square edges are usually recommended for butt joints in carbon steel and nonferrous metals and alloys for material ranging in thickness from 16 gage to $^5/_{16}$ inch. Butt joints in steel of thicknesses in excess of $^1/_2$ inch require special groove designs.

Backing Provisions

The same type of backing as that described for automatic shielded metal-arc welding is used.

Fit-Up

The same limitations on fit-up as that described for submerged arc welding are usually necessary.

5. AUTOMATIC ATOMIC HYDROGEN WELDING

Backing Provisions

The backing for atomic hydrogen welding is very important and may be

welded by this process. The automatic carbon-arc welding process is also used to weld nonferrous metals and alloys such as aluminum and aluminum-alloys and copper and copper-alloys.

Fit-Up

The same limitations on fit-up as that described for submerged arc welding are usually necessary.

5. AUTOMATIC ATOMIC HYDROGEN WELDING

Automatic atomic hydrogen welding is essentially the same as manual atomic hydrogen welding except for modifications and special provisions for automatically controlling the factors involved in the process.

Figure 6 shows an automatic atomic hydrogen welding head. In this process an arc is established between two tungsten electrodes which are surrounded by hydrogen. The hydrogen is supplied through a nozzle at the ends of the tungsten electrodes where it surrounds the arc and is dissociated into atomic hydrogen. The recombination of the atomic hydrogen to molecular hydrogen liberates heat which is used for welding. In observing the atomic hydrogen arc, it will be noted that a tongue-shaped flame surrounds the tungsten electrodes. The tip of this flame is held just above the surface of the work being welded. The size of the flame is controlled by the arc gap between the electrodes, which, in turn, is controlled by the arc voltage across the electrodes. Individual motors on each electrode are controlled through electrical circuit to maintain a constant arc voltage at all times. The intensity of the arc is controlled by the amount of current which is used in the arc.

Welding Current

Alternating current is used exclusively in atomic hydrogen welding. The open circuit voltage of the transformer supplying the current is approximately 300 volts. The arc voltage ranges from 50 to 100 volts, depending upon the size of arc desired.

Base Metal Composition

This process is used in welding low-carbon and high-carbon steels, low-alloy steels, high-alloy steels such as alloy tool steels, and nonferrous metals and alloys. The atomic hydrogen welding process is extensively used for light gages of all types of stainless steels. It is also widely used in welding Inconel, Monel and the heat-resisting alloys.

Thickness of Material

The thickness of material may vary from 0.008 to $^1/_2$ inch. For the welding of heavy sections, it is necessary to use a number of atomic hydrogen welding heads in series to obtain the heat required for penetration. For a single automatic head the maximum thickness which may be welded is approximately $^1/_8$ inch.

Speed of Welding

The speed of welding varies in a range from 3 inches to 90 inches per minute, depending upon such factors as fit-up, quality of the material, thickness of material, design of fixture and current used.

Edge Preparation

For material $^1/_8$ inch or less in thickness, square edges are used in butt joints. For thicknesses in excess of $^1/_8$ inch V-grooves are used, with the angle of the groove depending upon the thickness of the metal.

Backing Provisions

The backing for atomic hydrogen welding is very important and may be of copper or steel, plain or grooved. For some materials an open groove is maintained directly below the edges of the joint, and pure hydrogen is introduced into this space. This gas protection helps in obtaining full penetration and fusion of the weld metal on the bottom side of a single-pass weld. The presence of the hydrogen also prevents oxidation of the bottom side of the weld, and results in a bright surface, requiring no further cleaning or treatment.

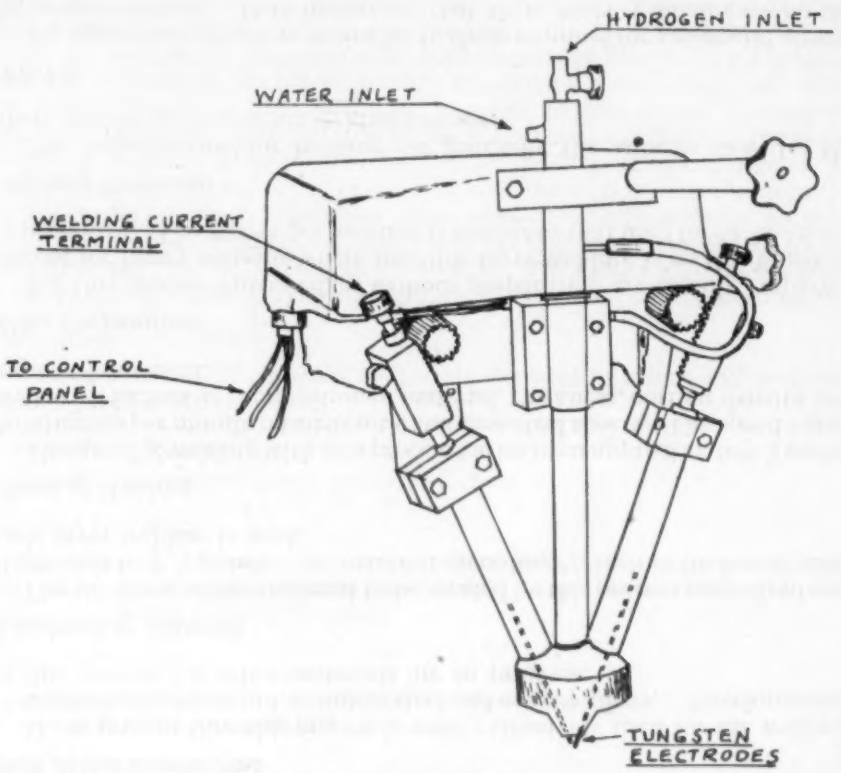


Fig. 6—Automatic Atomic Hydrogen Arc Welding Head with Provisions for Regulating the Welding Arc Length

Fit-Up

The fit-up for automatic atomic hydrogen welding is extremely critical and for uniform results on light gages it is necessary that the alignment of the abutting edges be held to within 10 percent of the thickness of the metal being welded. The gaps between abutting edges should not exceed 0.005 inch. The fixtures for holding the parts for welding must be very accurately made to maintain the strict tolerances required for welding with this process.

6. AUTOMATIC INERT-GAS SHIELDED METAL-ARC WELDING

Automatic inert-gas shielded metal-arc welding is essentially the same as manual inert-gas shielded metal-arc welding except that provision is made for mechanically moving either the electrode holder or the work so that welding can automatically progress along the joint.

A typical inert-gas shielded metal-arc welding torch is shown in Fig. 7. The essential parts of this equipment consist of a tungsten electrode which is surrounded by an inert gas such as helium or argon. An arc is maintained between the end of the tungsten electrode and the work to be welded. The torch must be water cooled and the arc length is maintained without the use

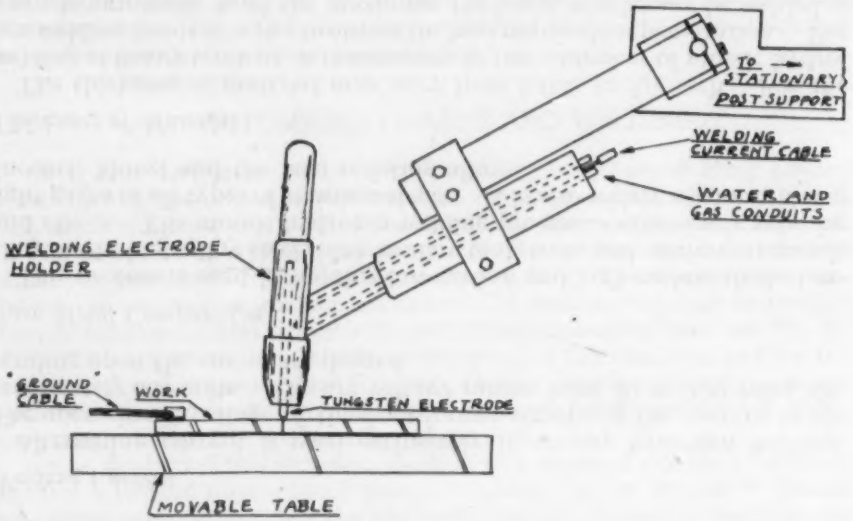

TO STATIONARY POST SUPPORT
WELDING CURRENT CABLE
WATER AND GAS CONDUITS
WELDING ELECTRODE HOLDER
GROUND CABLE
WORK
TUNGSTEN ELECTRODE
MOVABLE TABLE
AUTOMATIC WELDING IS ACHIEVED EITHER BY MECHANICAL MOVEMENT OF THE ELECTRODE HOLDER OR THE WORK

Fig. 7—Automatic Inert-Gas-Shielded Process

of elaborate electrical controls. With the use of argon, slight changes in the arc length do not materially affect the arc voltage. For automatic welding with this process, it is customary to mount the welding head in a fixed position, so that it is not necessary to continually adjust the arc length since the tungsten electrode is not appreciably consumed during welding.

The widest application for this process at the present time is for the welding of magnesium, aluminum, stainless steel and high-alloy and low-alloy steels.

Welding Current

Both alternating current and direct current are used. The polarity of the electrode on direct current will depend on the type of gas used for shielding and also on the material that is being welded. Some modifications of this process employ carbon electrodes in place of tungsten. This process was originally developed for welding of magnesium using helium. It was later adapted to the welding of other materials and the use of argon as well as helium for shielding.

The arc stability is considerably improved by using welding currents of high current densities. In some applications, high frequency current is superimposed on the welding current to obtain easier arc initiation and also to improve the welding stability of the arc. High frequency current superimposition can be used both with alternating current and direct current.

Base Metal Composition

At the present time this process is most extensively used for the welding of magnesium, aluminum, stainless steel and copper-alloys. Developments of this process for other materials are in progress.

Thickness of Material

The thickness of the material to be welded by this process may vary from 0.005 inch to $2^1/_2$ inches. On material exceeding $^1/_2$ inch in thickness, multiple layer welding is used.

Speed of Welding

The speed of welding with this process varies from approximately 3 inches to 90 inches per minute on austenitic stainless steel sheets. The speed varies with such factors as composition of material, thickness, current density and type of joint used.

Edge Preparation

For this process square edges without preparation are usually employed except for heavy sections where multiple layer welding is used a V-groove is necessary. The groove preparation is similar to that used for carbon steel.

Backing Provisions

The requirements for backing are generally the same as those for the inert-gas shielded metal-arc welding process.

Fit-Up

Fit-up limitations are very similar to those required for automatic atomic hydrogen welding. It is important that there be very small gaps on the lighter gages because no filler metal is added. The parts must be held rigidly in the fixture to prevent distortion during welding.

7. AUTOMATIC OXY-ACETYLENE WELDING

Automatic oxy-acetylene welding is the same as manual oxy-acetylene welding except that multiple flames are used and provision is generally made for moving either the torch or work so that the welding may progress along the joint.

This process usually consists of a water-cooled torch in which there are a number of flames for the heating operation. The length of the torch is designed according to the speed and thickness and type of material being welded. This process is being used for automatic welding of light gage steel tubes and for welding of light gage aluminum containers. The ratio of oxygen and acetylene can be varied to suit individual conditions.

In some applications, the welding torch is held stationary and the parts to be welded are moved under the torch. In other applications the work is held stationary and the torch is moved across the welding edges. For other applications, both torch and work are stationary.

In this process, the oxy-acetylene torch is usually designed for a specific welding application, and it is possible to design a torch which will weld the entire length at one time. An example of this is the welding of longitudinal seams in cylindrical sections. In this case, a torch of the same length as the seam is used. The torch may oscillate either transversely of longitudinally with the seam, in order to heat the sections more uniformly, and exceptionally high speeds are obtainable. Properly designed fixtures are necessary for automatic oxy-acetylene welding and provisions for water cooling of the jigs and torches are necessary. The fixture may be designed with a pressure follow up during welding to slightly upset the weld metal.

Base Metal Composition

This process is most generally adapted to the welding of low- and medium-carbon steels and aluminum.

Thickness of Material

The thickness may vary from 0.010 inch to $^1/_2$ inch.

Speed of Welding

The speed of welding may vary from 3 inches to 700 inches per minute depending upon the thickness of the material, composition of material, design of torch and welding fixtures.

Edge Preparation

Usually square edges are used in this process. On heavy sections, a V-groove is sometimes employed.

Backing Provisions

Usually copper backing bars, plain or grooved, are used. On low-carbon steel of light gage, no backing is required. Because of the large amount of heat used in this process, water cooling of the fixtures, clamps and backing is necessary.

Fit-Up

The requirements for fit-up are generally the same as those for the automatic atomic hydrogen welding.

Current Welding Literature

(*Continued from page 10*)

Electric Welding, Arc, Heliarc Process. Gas-Shielded Arc Processes, L. G. Pickhaver. Welding Engr., vol. 32, no. 11 (Nov. 1947), pp. 52–55, 58.

Electric Welding, Arc. Nonmagnetic Arc Welding Joints Between Mild Steel Plates, C. C. Frederick. Steel, vol. 121, no. 15 (Oct. 13, 1947), pp. 85, 124.

Electric Welding, Electrodes. Standard Specification for Iron and Steel Arc-Welding Electrodes. Can. Standards Assn.—Specification W48—1947, 38 pp., 75¢.

Electric Welding Machines, Automatic. New Full and Semi-Automatic Welding Machines, P. Sevbo and P. Paton. Engrs.' Digest (American Edition), vol. 4, no. 7 (July 1947), pp. 315–322; see also Engrs.' Digest (British Edition), vol. 8, no. 7 (July 1947), pp. 233–240.

Electric Welding, Power Supply. Causes and Cures for Hot Welding Cables, R. L. Townsend. Welding Engr., vol. 32, no. 10 (Oct. 1947), pp. 70–71.

Electric Welding, Resistance. Spot Welding of Dissimilar Aluminum Alloys in 0.040-Inch Thickness, W. F. Hess, R. A. Wyant and F. J. Winsor. Nat. Advisory Committee Aeronautics—Tech. Note no. 1322 (Oct. 1947), 17 pp., 18 supp. sheets.

Electric Welding, Resistance. Flash Welding—Theory and Practice, W. H. Cochran. Iron Age, vol. 160, no. 16 (Oct. 1947), pp. 150–154.

Electric Welding, Resistance. Future of Resistance Welding in Canada, W. W. Brumby. Elec. News & Eng., vol. 56, no. 18 (Sept. 15, 1947), pp. 55, 94, 96.

Excavating Machinery, Manufacture. Mechanized Welding and Cutting Employed in Fabricating Heavy-Duty Earth Movers, E. Griffeth. Steel, vol. 121, no. 17 (Oct. 27, 1947), pp. 80–84, 111, 114.

Gasoline Tanks, Welded Steel. Applying Resistance Welding in Tank Production. Machy. (N. Y.), vol. 54, no. 3 (Nov. 1947), pp. 156–158.

Grinding Mills, Manufacture. Arc Weld Fabrication of Ball Mills, J. F. Cunningham, Jr. Iron Age, vol. 160, no. 17 (Oct. 23, 1947), p. 43.

Industrial Trucks. Fabricating Hand Trucks by Welding, K. Stad. Tool Engr., vol. 19, no. 4 (Nov. 1947), p. 42.

Iron Castings. Cylinder Head Welding, T. B. Jefferson. Welding Engr., vol. 32, no. 11 (Nov. 1947), pp. 33–35.

Iron Castings. Welding in Iron Foundry, H. E. Schultz. Foundry, vol. 75, no. 10 (Oct. 1947), pp. 78–80, 136, 139.

Jig and Fixture Economics—Importance of Efficient Clamping, B. R. Pyke. Sheet Metal Industries, vol. 24, no. 247 (Nov. 1947), pp. 2250, 2257.

Light Metals. Aluminum Alloys for Gas Welding with Special Reference to Aluminum-Silicon-Copper Alloys, J. Pendleton and E. A. G. Liddiard. Sheet Metal Industries, vol. 24, no. 246 (Oct. 1947), pp. 2062–2066, 2068; no. 247 (Nov.), pp. 2273–2278, 2280.

Locomotive Boilers. All-Welded Locomotive Boiler Construction, Canadian Pacific Railway. Ry. Gaz., vol. 87, no. 9 (Aug. 29, 1947), pp. 239–241.

Metals, Hard Facing. Automatic Flame-Hardening, M. R. Nelson. Machy. (N. Y.), vol. 54, no. 3 (Nov. 1947), pp. 150–153.

Metals, Hard Facing. Electrode Selection for Hard Facing. Metallurgia, vol. 36, no. 215 (Sept. 1947), pp. 278–279.

Metal Working. Factors Affecting Choice of Metal Joining Processes, J. L. Miller. Sheet Metal Industries, vol. 24, no. 246 (Oct. 1947), pp. 2051–2057, 2061.

Natural Gas Pipe Lines, Welding. Laying "Biggest Inch" Pipe Line. Welding Engr., vol. 32, no. 10 (Oct. 1947), pp. 42–43.

Natural Gas Storage. Welding Takes Gas Storage Underground, J. H. Giroux. Welding Engr., vol. 32, no. 11 (Nov. 1947), pp. 56–58.

Oil Field Equipment. Pressure Welding, A. L. Burns, Jr. World Oil, vol. 127, no. 6 (Oct. 1947), pp. 92, 94, 96, 98.

Oxyacetylene Welding. "What Gas Pressure Shall I Use?" E. L. Mathy. Western Metals, vol. 5, no. 7 (July 1947), pp. 30–31.

Oxy-Gas Welding. Flames for Welding, T. Courard. Engrs.' Digest (American Edition), vol. 4, no. 8 (Aug. 1947), pp. 370–374; see also Engrs.' Digest (British Edition), vol. 8, no. 8 (Aug. 1947), pp. 256–260.

Oxy-Gas Welding. Proper Handling of Gas Welding Equipment, C. C. Hermann. Power Plant Eng., vol. 51, no. 5 (May 1947), pp. 86–87.

Oxygen Cutting. "Oxyarc" Cutting. Engineer, vol. 184, no. 4784 (Oct. 3, 1947), p. 317.

(*Continued on page 47*)

Welding Current

Both alternating current and direct current are used. The polarity of the electrode on direct current will depend on the type of gas used for shield-

Storage Battery Work

By L. S. Bowser*

LEAD that has been subjected to the action of a strong acid is more difficult to weld than new or clean lead. Parts that have been in contact with the sulphuric acid used in storage batteries, for example, require even more thorough cleaning than other lead members. A solution of ammonia or sodium bicarbonate can be used to neutralize the acid if it can be applied without spilling any into the battery. The procedure more commonly used is to wipe dry the parts to be welded and then scrape them bright. The scraping removes the layer of lead affected by the acid and prepares a sound, easily fused surface for welding. Care should be taken to protect skin and clothes from any contact with the acid.

A "burning" rack or comb, as shown in Fig. 1, is used to space and align plates for welding to plate connectors. After the plates are positioned so that the lugs extend above the top of the comb, the post is set in place. A comparatively large flame is then directed at the ends of the lugs. When they are molten, metal from the welding rod is added to form a strap, fusing the lugs together and to the post.

Where a slotted plate strap or connector is used, plates are set in the comb with lugs extending up into the slots of the strap. The welding flame is then directed along the sides of the slots so that they are brought to the melting point at the same time as the lugs. When these surfaces are fused, metal from the welding rod is added to fill up the slots and complete the weld. The strap is then filed smooth.

* The Linde Air Products Company, Boston, Mass.

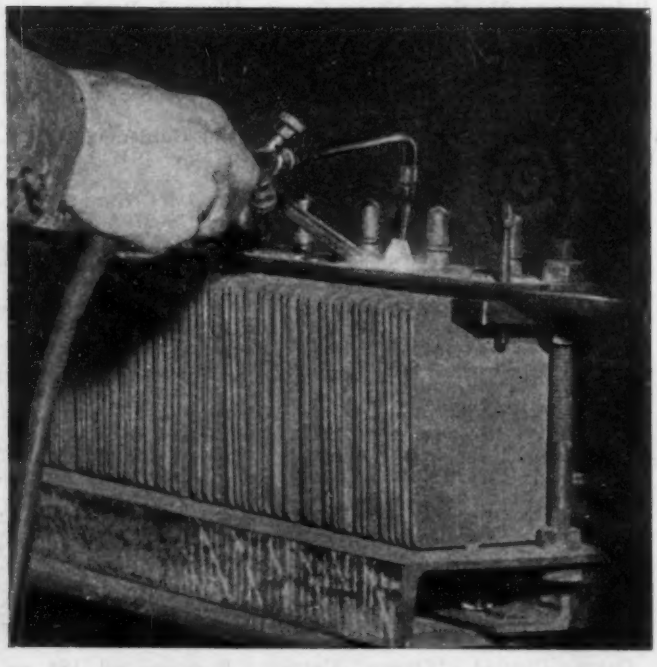


Fig. 1—In Welding Plates to Plate Connectors, a Comparatively Large Flame Is Used to Fuse the Lugs Together and to the Post. The Entire System Is Held Rigidly in an Iron Frame

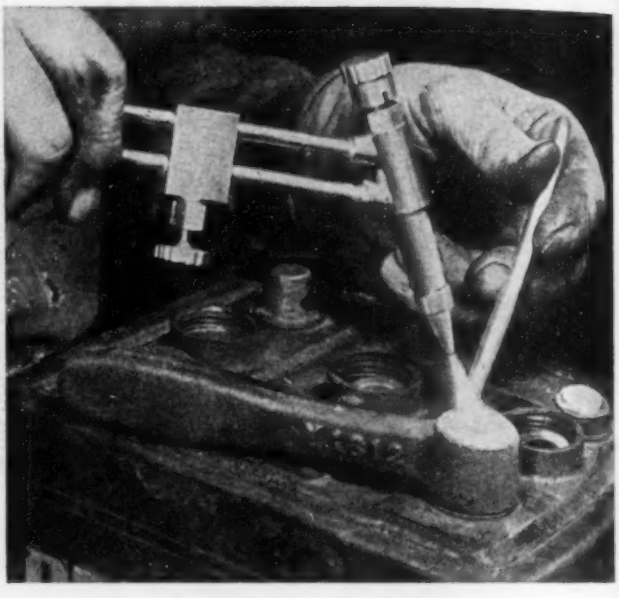


Fig. 2—When Terminal Posts Are Built Up, a Cast-Iron or Sheet Metal Mold Is Used to Form the Molten Metal

Cell Connectors and Terminals

Connectors are fitted snugly around terminal posts by tapping with a small wooden mallet. Proper fit requires a space of about $1/4$ in. between the top of the post and the upper surface of the connector or terminal. Where necessary, the post is cut off to obtain this spacing. In welding, the top of the post and the inner wall of the connector are melted by the flame at the same time. As a

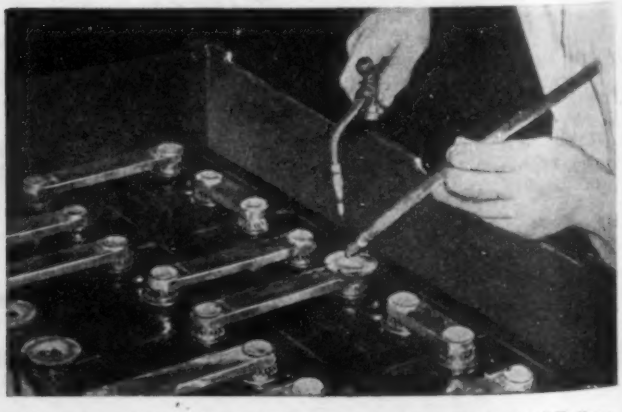


Fig. 3—A Connector Is Welded on a Large Industrial Battery After a Repaired Cell Has Been Installed

molten pool forms, metal from the welding rod is added and mingled with additional metal from the inside wall of the connector. The flame is withdrawn and the metal is allowed to cool as often as seems necessary to prevent the lead from running too rapidly. When the post has been built up flush with the top of the connector, it is allowed to cool. After wire brushing, the top is finished by applying the flame again and adding just enough welding rod to smooth off the surface. If insulated cable is imbedded in the terminal, a strip of wet cloth is wrapped around the insulation to prevent it from burning.

A terminal post, drilled out while tearing down a battery, is easily rebuilt if a mold is used to form the metal. The mold may be cast, as in Fig. 2, or made of sheet metal. The opening, in which the post is formed, should be slightly tapered so that the mold can be removed easily from the finished work. In welding, care must be taken that the top of the post is molten before adding welding rod. Unless this is done, the metal will not fuse solidly and the joint is likely to be weak.

Let Contraction Do the Heavy Work

By E. F. Kurzinski*

IN CERTAIN welding operations, structural shapes, piping, sheet and plate metal may become warped or distorted. This is caused by expansion and contraction forces set up by the high temperatures used to weld the parts. The heat, concentrated in a small area around the welding zone, causes that part of the metal to expand. The surrounding mass of unheated metal acts like a vise, directing most of the expansion so that the heated area upsets and becomes thicker than it was when cold. As the weld area cools, contraction forces try to pull the part back to its original size and shape by "unpiling" the upset metal. But this metal increases in strength as the temperature drops. It is easier for the contraction forces to pull the whole piece of metal out of shape than to thin out the thickened section.

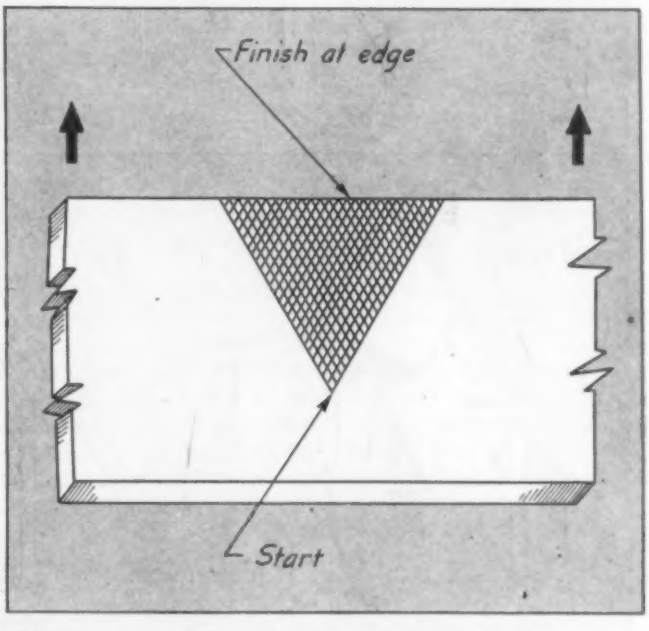
Straightening

Contraction caused the distortion. Why not use the same force to straighten the piece? You can do this quickly and easily with the oxyacetylene flame. Use the blowpipe to heat a wedge or triangular-shaped area on the outside of the bend, as shown in the sketches. Then let it cool. Contraction forces will pull the part back toward alignment. If further straightening is needed, heat another area next to the first and let it cool again. Repeat as many times as necessary to bring the part back into line, but don't heat the same spot more than once if you can help it.

The ends of the part will always be drawn toward the side on which the widest part of the heated wedge is located. How much the part straightens with each heating depends on the size of the area heated and how well the heat is localized. To get maximum straightening, it is often desirable to cool the heated area again quickly. You can do this by quenching the hot metal with water or compressed air. Ordinary low carbon steels may be heated to about 1600° F. (bright red) and quenched in this way without harm.

The same methods will also save you time and work in straightening metal parts that have been bent cold by blows or overloading. In such a part, metal around the point of bend has been stretched so that the area is thinner and weaker than it was before the damage was done. During the flame-straightening operation, the stretched area is upset and thickened to restore its original strength.

Because no two straightening jobs are alike, it is not possible to specify the exact size of the area to be heated. As a rough guide, the amount of contraction along the outside of the bend may be estimated at the rate of $^1/_8$ in. per foot of heated metal when heated to the temperatures commonly used by the blacksmith for similar work. With experience, it will become a simple matter to heat the part only once or twice to bring it back into line in a few minutes.



If You Heat a Flat Bar Like This (Shaded Area), Contraction Forces During Cooling Will Pull the Ends in the Direction of the Arrows

In the beginning, you can avoid over-correction by heating a somewhat narrower vee than shown in the sketches and repeating to bring the part into line a little at a time. It may help also to chalk an outline of the area to be heated. Should the part bow in the opposite direction from overheating, let it cool, or quench it. Then heat on the opposite side to bring it back into alignment.

Equipment

Your standard welding outfit, always available anywhere in the shop, is all you need for heating jobs on

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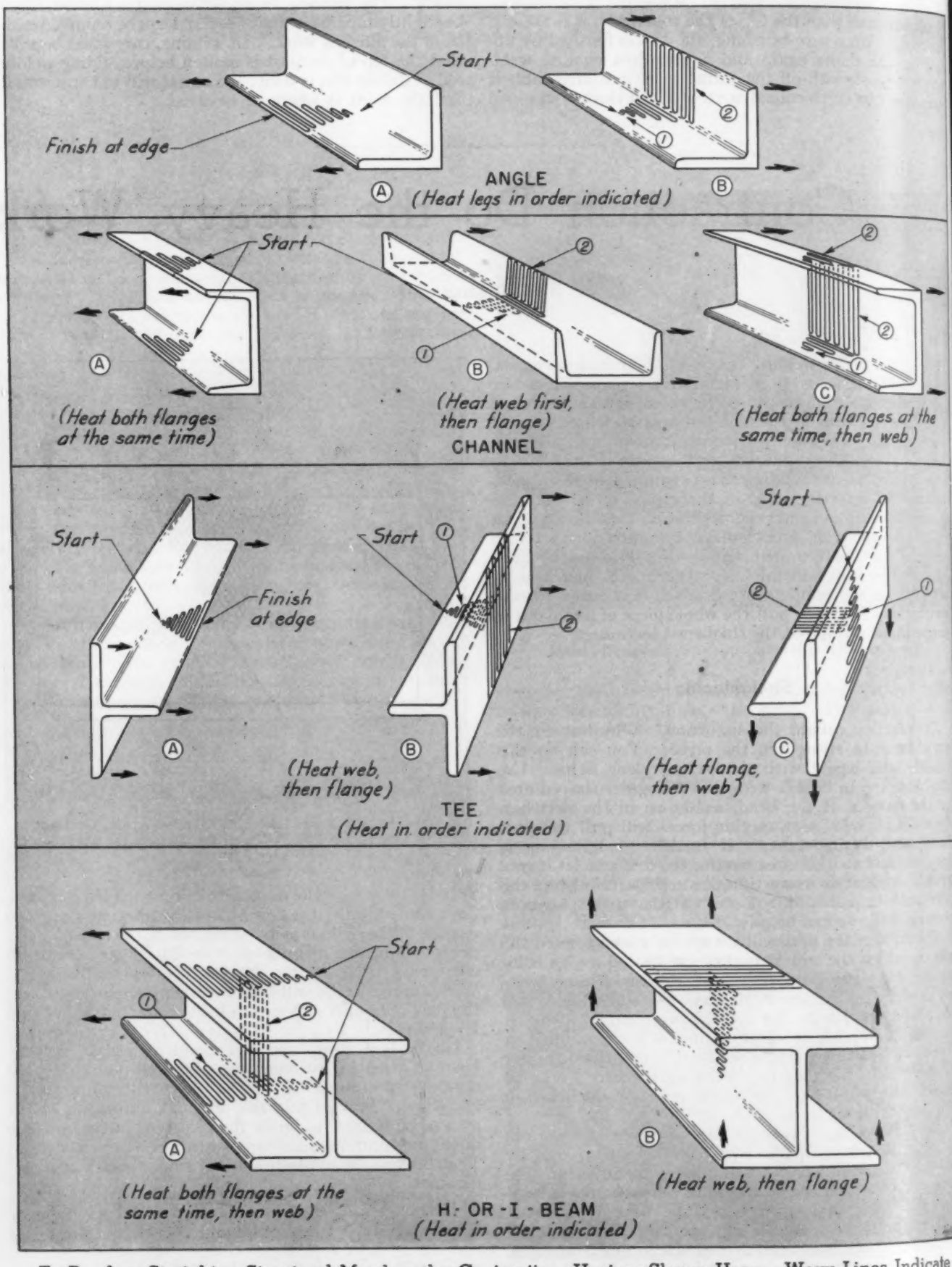
metal thicknesses within the welding range of the blowpipe. For very heavy work, larger capacity blowpipes with multiflame heads are more efficient. But in every case, the oxyacetylene blowpipe is the handiest tool for instantly applying heat without waste to the exact area where it is needed.



To Bend or Straighten Structural Members by Contraction, Heat as Shown Here. Wavy Lines Indicate Path of the Blowpipe Flame. Arrows Show Direction Ends Will Be Pulled During Cooling

Multiple Flame Pressure Welding Process*

By N. H. Cuke†

PRESSURE welding consists essentially of heating the weld zone of pieces to be joined to a high temperature by multiple oxyacetylene flames, and applying pressure normal to the weld faces to force the pieces to bond together.

There are two distinct methods of pressure welding, both applying the principles outlined above but in different ways and with somewhat different results.

Solid Phase Pressure Welding

The first method has been called "closed-butt" or "closed-joint pressure welding" or "solid phase pressure welding." During the past three or four years, considerable experimental work has been conducted and numerous papers written on this method of pressure welding.[1–10, 13] In this method the weld faces are in contact during the complete welding cycle. The weld zone is heated by multiple oxyacetylene flames to a high temperature but not to the melting temperature of the metal. The temperature the metal attains brings it to the plastic state but at no time does the metal actually melt. Hence the term "solid phase welding" as the welding or bonding takes place in the solid state or solid phase. Pressure is applied in a direction normal to the weld faces causing an upsetting or a plastic deformation of the metal in the weld zone. It is this combination of heat and pressure that causes the pieces to weld or bond together. Considerable variations in the cycle have been used, particularly in the application of the pressure. The maximum pressure used is sometimes applied at the beginning of the heating part of the cycle and allowed to remain until the metal reaches the plastic state and upsetting occurs. Or a low initial pressure may be used and the high pressure applied only when the metal has reached the plastic state. Or the pressure may be applied gradually or at regular or various intervals. Various temperatures and rates of heating have been used as well as various methods of oscillation of the burners, and various amplitudes and periods of oscillation. The best procedure depends on the application, that is, the design of the parts, the type of metal, etc.

The process is being applied commercially to many items such as railroad rails,[4] overland piping,[5, 6] liquefied gas cylinders,[3] alloy steel tubing,[7] aircraft landing gear[8–10] and many other parts which have not as yet been publicized.

Fusion Pressure Welding

The other method of pressure welding may be called "open-butt" or "open-joint pressure welding," or "fusion pressure welding" and is the one with which we are chiefly concerned in this paper. Very little has appeared in the literature on this method of welding. One reason for this is believed to be that when the idea was conceived of applying pressure to a heated joint to cause an upsetting and bonding, the disadvantages of the open-butt method seemed very apparent, so much so as to overshadow its advantages. Also, the first few research or experimental programs conducted on the closed-butt method gave results which appeared to be better than they actually were. The first researchers, through no fault of their own, showed that the weld line disappeared completely through crystal growth across the interface and diffusion of the oxides or nonmetallic particles from the interface into the base metal. Standard metallographic etching reagents such as "nital" were used in the microscopical studies. Since then a new etching reagent, "alkaline chromate,"[11, 12] has brought out the fact that the weld line does not disappear and does contain considerable dissolved oxygen or oxides.[7, 10, 11, 13]

In open-butt or fusion pressure welding the parts to be joined are held a short distance apart during the heating cycle as shown in Fig. 1. When the correct temperature is reached the parts are brought together and pressure applied to cause an upsetting of the metal in the weld zone. The weld faces are brought to the melting temperature before the pressure is applied. Therefore the bond is, at least in part, a fusion weld.

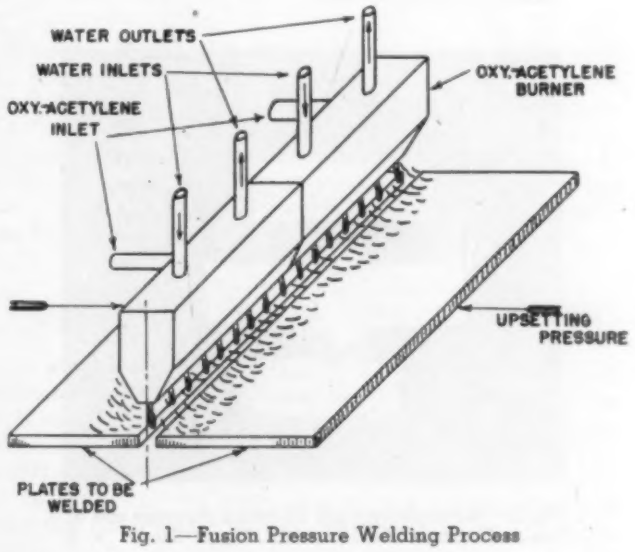


Fig. 1—Fusion Pressure Welding Process

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* Presented at Twenty-Eighth Annual Meeting, A.W.S., Chicago, Ill., week of Oct. 19, 1947.

† Development & Engineering Dept., Canadian Liquid Air Company, Ltd., Montreal, Quebec, Canada.

Oxyacetylene Burner

The multiple flamed oxyacetylene burner is suspended between and above the weld faces, and is oscillated back and forth along the line of the weld. The burner is oscillated to obtain even heating of the weld faces but the amplitude and period of oscillation are not critical factors. Naturally the amplitude must be at least as great as the distance between consecutive flame orifices of the burner and the center line of the burner must always be parallel to the weld faces.

The flames of the burner may be in a single row and parallel to the weld faces as in Fig. 1, or they may be in a double parallel row, or they may be in a double row with the flames directed at the weld faces either normally or at an angle. However, the double parallel row of flames, while often found beneficial in solid phase welding, has very little if any advantage over a single row in fusion pressure welding and, besides, it uses more oxygen and acetylene. It is also questionable whether a burner having the flames directed at the weld faces has any particular advantage. Possibly the weld faces are brought to the melting temperature quicker as the flames are directed at or impinge upon the weld faces. However, the time it takes to reach the melting temperature with the single row of flames is very short and faster heating only makes the process difficult to control. Furthermore, faster heating means that less metal adjacent to the melted surfaces reaches the plastic temperature which has a detrimental effect on the quality of the weld.

Preparation of Weld Faces

The preparation of the weld faces is a very important factor in solid phase welding if high strength quality welds are to be obtained. However, for fusion pressure welding the weld faces need not be too carefully prepared, that is, they do not need to be machined or polished. Shearing produces surfaces quite satisfactory for good welding because any minute voids or rough spots are eliminated when the surfaces are melted. However, the surfaces should be free of scale or rust to limit the amount of oxide inclusions in the weld.

Flame Characteristics

A strictly neutral flame is used. It is a well-established fact that if acetylene and oxygen are mixed in equal proportions by volume the oxygen combines with the acetylene in the inner cone of the flame to form carbon monoxide and hydrogen. The carbon monoxide and hydrogen then burn as an outer or envelope flame to form carbon dioxide and water vapor. The oxygen required for this secondary combustion is obtained from the surrounding air. The products of the primary combustion have a definite beneficial effect on the molten metal. They are neither carburizing or oxidizing but are actually reducing in character, forming a protective reducing atmosphere for the molten metal. Furthermore, they tend to obtain some of the required oxygen for the secondary combustion from any dissolved oxygen or oxides in the molten metal.

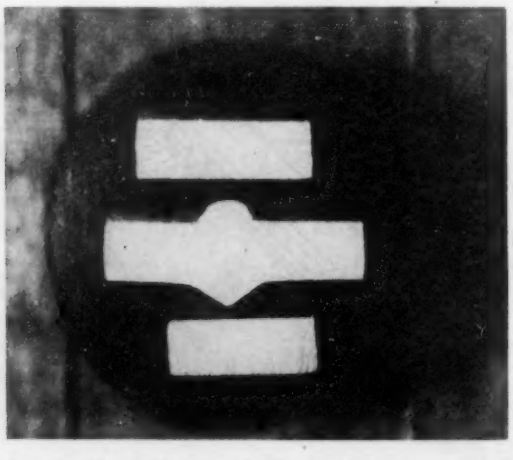

Fig. 2—Macrophotograph Showing Appearance of Fusion Pressure Weld in 4-Mm. Sheet Steel. × 2

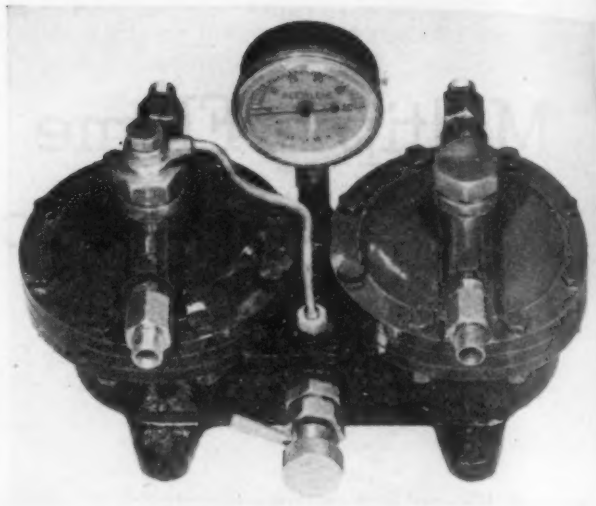

Fig. 3—Oxyacetylene Pressure Equalizer

Appearance of Weld

The appearance of the weld as shown in Fig. 2, is somewhat different to that produced by solid phase welding. In the latter process the upsetting is considerable and rounded, tapering off gradually, while the upset with the fusion pressure process is small and rounded on top, but tapering off rapidly, and triangular or pointed on the bottom. In fusion pressure welding, while some of the metal reaches the melting temperature, less metal reaches the plastic state, hence the upsetting does not extend as far back into the metal on either side of the weld line.

Positioning of Weld Components

The spacing of the parts to be welded in relation to one another and in relation to the oxyacetylene flames is very important and quite critical. Their positions depend on the application, that is, on the thickness of the metal and on the design of the burner and the gas pressures used.

Like flash welding or solid phase pressure welding the fusion pressure welding process should be operated automatically and the closer the setup approaches to being fully automatic the better. In any automatic welding setup the quality of the welds depends on the accuracy of the mechanical jigging and the degree of control obtained over the variables on the process. It can easily be seen that the spacing of the plates in relation to one another and to the burner, the accuracy of oscillation of the burner and the evenness of application of the upsetting pressure along the weld line are important factors, but they are factors that are purely mechanical and,

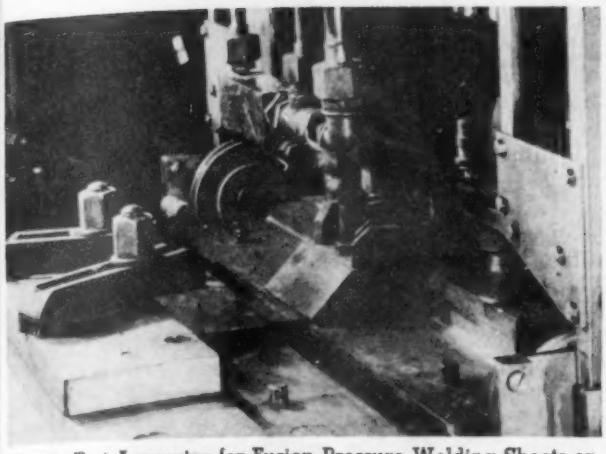

Fig. 4—Test Apparatus for Fusion Pressure Welding Sheets or Plates with Burner in Raised Position

with good mechanical design, should not cause any trouble.

Control of Process

The control of an automatic or semiautomatic process is probably its most important feature. In solid phase welding the pressure is applied during the heating of the weld zone and the process is usually controlled by the amount of shortening of the parts due to the upsetting. In fusion pressure welding the pressure is applied after the heating part of the cycle and the control must be placed on the duration of heating. The duration of heating is very short in comparison with solid phase welding, usually five to ten seconds, and its control is very important. If the pressure is applied too soon there is insufficient fusion at the weld faces and the plastic zone is not deep enough to produce a good weld. If the pressure is applied too late the molten metal begins to drip and the upsetting is spongy and porous and the weld is of poor quality. However, while the timing is important there is, nevertheless, a small range and the process can actually be controlled manually by a good operator although for a production setup an automatic timing device is advisable to ensure 100% consistency of quality welds.

Regulation of Gas Pressures

Since the duration of heating is the only method of controlling the process, any factors which tend to influence the heat input during the heating part of the cycle must be held constant—constant during each weld and constant from weld to weld. As mentioned previously,

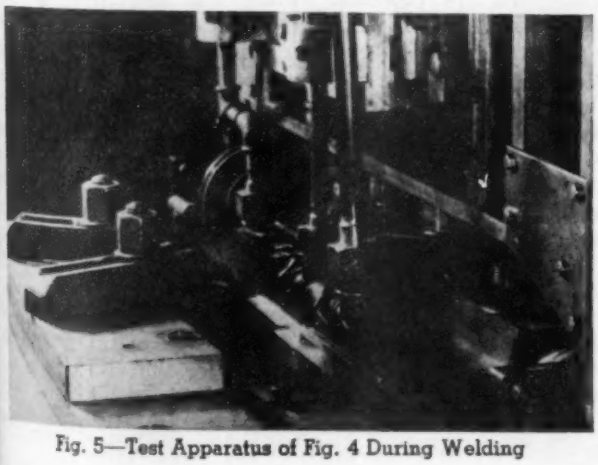

Fig. 5—Test Apparatus of Fig. 4 During Welding

the positioning of the parts to be welded and the burner is important but these can be held constant by good mechanical design. However, it is not quite so simple to limit variations in the operation of the oxyacetylene equipment. The design of the burner must be such that all the flames are balanced. Then the gases must be supplied to the burner at a constant pressure or flow. This is about the most difficult part of the process. Even the best of the standard regulators made today fluctuate sufficiently to make it difficult to maintain constant welding conditions. However, we have developed a "pressure equalizer," Fig. 3, that will deliver both the oxygen and acetylene to the mixing chamber of the torch at equal pressures to a high degree of accuracy. The oxygen and acetylene are delivered separately from their sources to the equalizer through standard regulators. The delivery pressure of the equalizer may be set to any value desired. However, due to the difficulty of accurately reading the pressure gage mounted on the equalizer, a flowmeter is installed in the oxygen line between the equalizer and the torch and the pressure regulated at the equalizer to

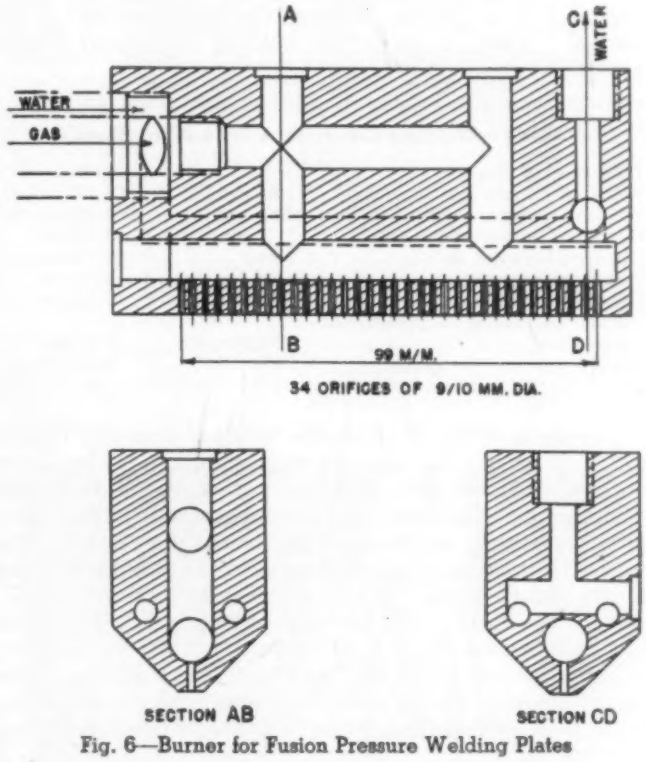

Fig. 6—Burner for Fusion Pressure Welding Plates

give a predetermined flow. The flowmeter can be read very accurately and thus the welding conditions can be repeated accurately from day to day or after shutdowns.

Our research laboratories have for some time now been conducting a program investigating the potentialities of the fusion pressure welding process. So far the work has been restricted to low-carbon steel. The results have been very successful.

Fusion Pressure Welding Low-Carbon Steel Sheets

One series of tests was conducted on plates 4 mm. in thickness and 100 mm. in width. Figure 4 is a photograph of the test apparatus used with the sheets in position and the burner in the raised position. The clamp at the left is fixed while the clamp at the right is movable. The two tubes on the left of the burner are the inlet and outlet for the cooling water and the tube on the right supplies the oxyacetylene mixture to the burner. Figure

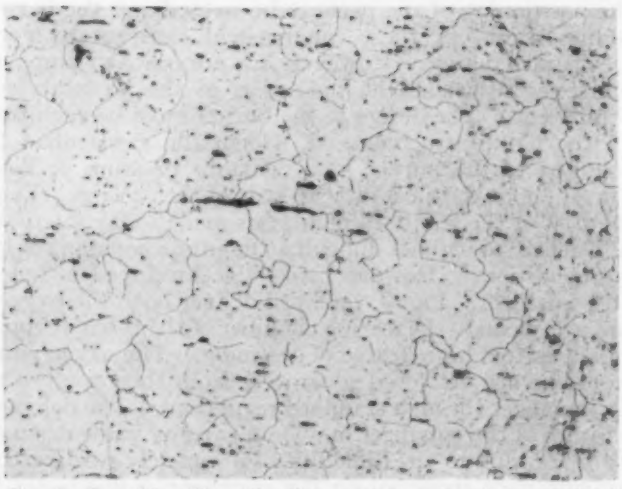

Fig. 7—Four-Mm. Sheet Far Removed from Weld Zone. Nital Etch. × 100

5 is a photograph taken during the welding operation. Figure 6 is a sketch showing the construction of the burner. Table 1 gives the welding conditions finally arrived at during the tests.

Table 1—Welding Conditions for 4-Mm. Sheets

Thickness of sheets	4 mm.	0.1575 in.
Width of sheets	100 mm.	3.94 in.
Welding surface	400 mm.^{2}	0.62 sq. in.
Height of burner above sheets	7.7 mm.	0.303 in.
Distance between sheets	2 mm.	0.079 in.
Upsetting pressure	3.18 kgs./mm.^{2}	4522 psi.
Duration of heating	5.25 sec.	5.25 sec.
Oxygen and acetylene pressure at equalizer	220 gms./cm.^{2}	3.1 psi.
Oxygen and acetylene flow	2550 l./hr.	90 cu. ft./hr.

The microscopic study of the welds is shown in Figs. 7 to 10. Figure 7 is a microphotograph taken in the sheets far removed from the weld zone. It shows the steel to be very low carbon, dirty and coarse-grained. The inclusions are strung out horizontally in the direction of rolling. Figure 8 shows the weld zone at approximately the center of the sheets. The weld line is vertical in approximately the center of the microphotograph. The fiber has been turned through 90°, resulting from the pressure causing the soft metal to flow toward the surfaces. The actual welding line is indistinguishable as expected because there is definite melting of the weld faces, resulting in crystallization across the weld line on cooling from the melting temperature. The general vicinity of the line can be distinguished, as there is an area where there is an absence of the large nonmetallic inclusions, although there is possibly a slight increase of the small inclusions. It is difficult to determine exactly what has happened to the large inclusions. Possibly they dissolved in the molten metal and then precipitated out as fine particles during solidification or possibly they were reduced considerably by the reducing atmosphere of the flames. Whatever the cause, the steel does seem to be more sound in this area. Further microscopic study showed that the narrow area of fine inclusions, shown in Fig. 8, widened out as the surface was approached and the upset contained only fine inclusions. Figure 9 is the same area as Fig. 8 repolished and etched in alkaline chromate solution. The alkaline chromate solution was prepared and used as suggested by Leslie Fine.[11] It did not reveal any white areas, indicative of oxygen, in or near the welds. Figure 10 shows the worst part of the weld. The top of the microphotograph is the surface of the upset or bead on the upper side of the sheets. The upset often has a porous zone with slag inclusions near the surface, but it never extends down far enough to have any adverse effects on the physical properties of the weld.

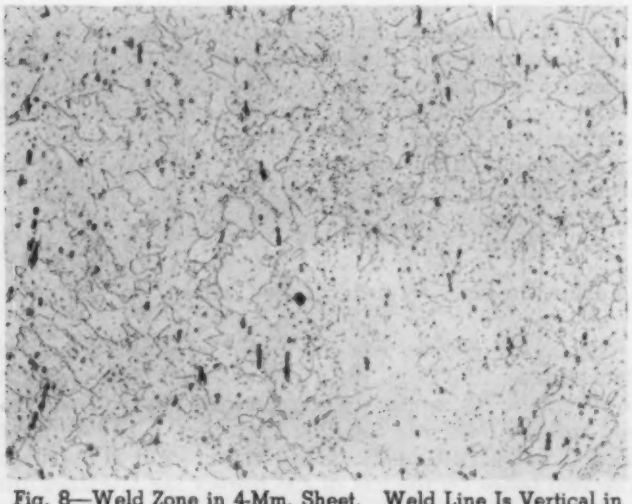

Fig. 8—Weld Zone in 4-Mm. Sheet. Weld Line Is Vertical in Approximately the Center of Microphotograph. Nital Etch. × 100

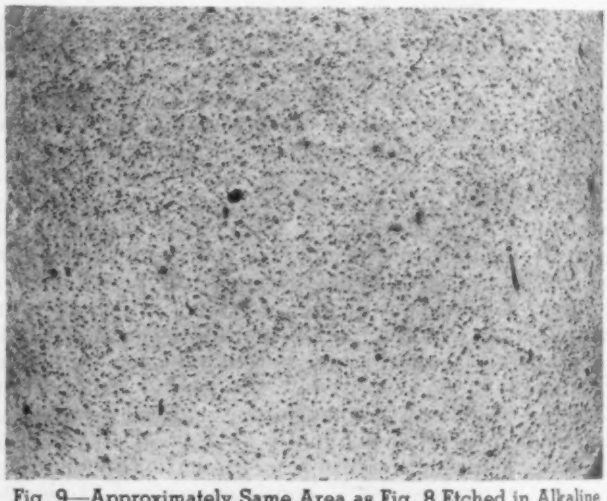

Fig. 9—Approximately Same Area as Fig. 8 Etched in Alkaline Chromate. × 100

The welding conditions shown in Table 1 were arrived at after numerous tests and were only considered ideal or final after 15 consecutive perfect welds were made. The physical testing of the welds did not consist of either tensile or elongation tests because, actually, the tests were conducted with a practical commercial application in mind—the joining of strip ends before cold rolling. Therefore, the physical testing was limited to the behavior of the welds under cold rolling. The upsetting on both sides of the sheets was removed by grinding, bringing the thickness at the weld zone down to the original thickness of the plates, that is, 4 mm. The 15 sheets were then reduced in thickness by cold rolling, in four passes, from 4 mm. to 1.2 mm. The sheets were not given any heat treatment whatever, that is, the sheets were rolled in the "as-welded" condition. None of the test pieces broke or showed any signs of cracks or failure. The test pieces, after cold rolling and without annealing, were subjected to bend tests. The angle at which cracking first appeared was less in some of the samples bent at the weld line than those bent in the base metal but, on the whole, the results were too erratic, that is, failure occurred over such a wide range in bends at both the weld line and in the base metal that it was impossible to draw any definite conclusions from the bend tests.

Tests were conducted on other sheets of various thicknesses and it was found that, like manual oxyacetylene welding, the gas flows of the burner should be adapted to the thicknesses of the pieces being welded. The burner shown in Fig. 6 was found to be suitable for sheets with thicknesses from 3 to 5 mm. A burner similar to Fig. 6, but with the flame orifices reduced from $^{9}/_{10}$ mm. to $^{6}/_{10}$ mm. diameter, was found suitable for thicknesses from 1 to 3 mm. Tests were conducted on sheets of 2 mm. thickness and Table 2 gives the welding conditions for this thickness. Like the tests on the 4-mm. sheets, 15 perfect consecutive welds were made and subjected to cold-rolling tests—reduced in three passes without heat treatment from 2 mm. to 0.8 mm. thickness. No failures or cracking occurred.

Table 2—Welding Conditions for 2-Mm. Sheets

Thickness of sheets	2 mm.	0.079 in.
Width of sheets	95 and 105 mm.	3.74 and 4.13 in.
Height of burner above sheets	4.2 mm.	0.165 in.
Distance between sheets	1.2 mm.	0.047 in.
Upsetting pressure	3.2 kgs./mm.^{2}	4550 lb./sq. in.
Duration of heating	4.8 sec.	4.8 sec.
Oxygen and acetylene pressure at equalizer	220 gms./cm.^{2}	3.1 lb./sq. in.
Oxygen and acetylene flow	1.75 m.^{3}/hr.	61.8 cu. ft./hr.

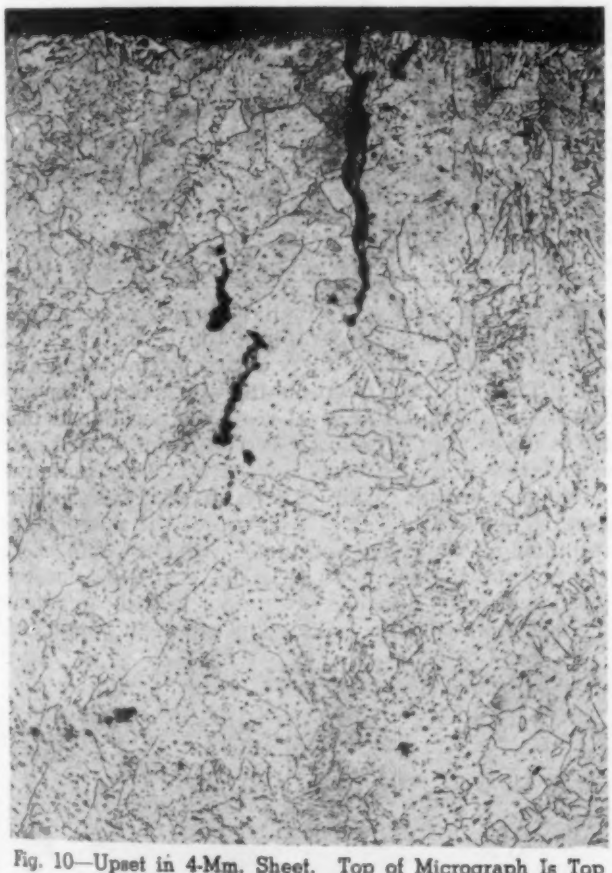

Fig. 10—Upset in 4-Mm. Sheet. Top of Micrograph Is Top Surface of Upset. Nital Etch. × 100

Timing and Duration of Heating Part of Cycle

In the tests conducted on both the 2- and 4-mm. sheets, it was found that the duration of heating could be varied over an appreciable range of $^{2}/_{5}$ of a second, that is, $^{1}/_{5}$ of a second on either side of the figures given in Tables 1 and 2.

As a general rule, optimum results with the process are obtained with a duration of heating between 5 and 7 sec. The welding conditions, naturally, may be varied to produce good welds for any duration of heating desired. However, a duration of heating below the recommended time gives results which are less regular and very difficult to control. A duration of heating longer than the recommended time needlessly wastes heat and gases and, due to the slower heating of the pieces to be welded, more of the metal back of the weld faces reaches the plastic temperature giving excessive or accentuated upsetting when the pressure is applied.

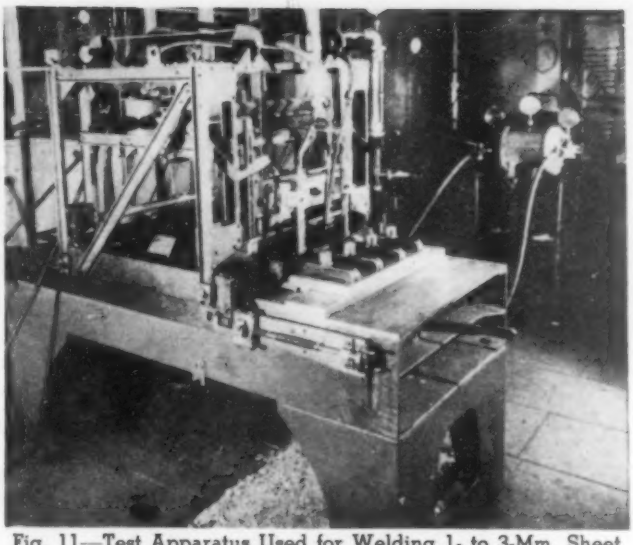

Fig. 11—Test Apparatus Used for Welding 1- to 3-Mm. Sheet Steel with Burner in Welding Position

Welding Sheets of Different Thicknesses

Our laboratories recently completed another interesting series of tests for a large automobile manufacturer, the butt welding of mild steel sheets of different thicknesses, one 3 mm. and the other 1 mm. The test apparatus, Fig.

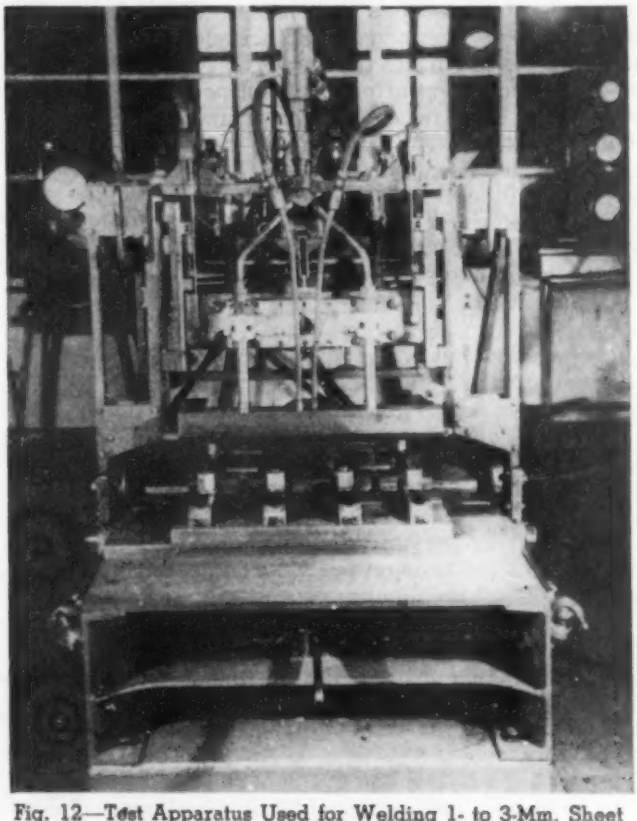

Fig. 12—Test Apparatus Used for Welding 1- to 3-Mm. Sheet Steel with Burner in Raised Position

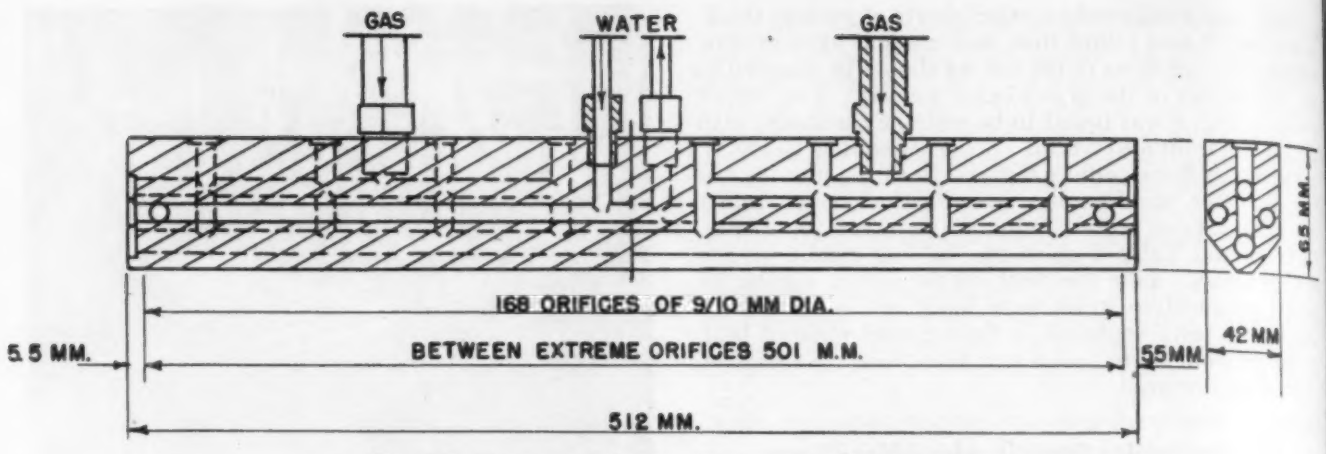

Fig. 13—Burner for Fusion Pressure Welding Plates

11, was more elaborate than that used in the previous experiments reported. This photograph shows the apparatus in place ready for the welding operation while Fig. 12 indicates the position of the apparatus once the welding has taken place and the burner removed. The equipment consists of three essential parts—the welded stand or frame, the sets of vises or clamps (the one on the right is fixed, while the other is mobile) and the carriage which is mobile and supports the various accessories such as torch, burner, electric motor for oscillating the burner, the oscillating guides, positioning and lifting arrangements for the burner, etc. The upsetting pressure is applied to the mobile clamps by a compressed air-actuated piston (hidden in photographs). Adjustable stops are provided on each side of the base frame for accurate positioning of the movable carriage, and hence the burner, in the welding position. Once the plates to be welded have been clamped, the burner positioned and the correct pressure for the oxygen and acetylene set on the equalizer, a timing system controls the process. That is, it automatically opens the oxygen and acetylene valves, lights the burner, extinguishes the flames by closing the oxygen and acetylene valves after a certain period of time and, at the same time, raises the burner and applies the upsetting pressure. In lighting the burner, the oxygen valve is opened a fraction of a second ahead of the acetylene, while in extinguishing the flames, the acetylene valve is closed a fraction of a second ahead of the oxygen valve.

The positioning of the sheets to be welded in relation to one another and the burner as in the other tests is very important. The sheets are placed such that the top surfaces are level with one another or, in other words, in the same plane. The burner is positioned with the flames closer to the 3-mm. sheet so that the weld faces of both the 1- and 3-mm. sheets begin to melt simultaneously. Table 3 gives the welding conditions for this series of tests. The burner shown in Fig. 13 was used for the tests.

The upsetting pressure is much less for this series of tests than for the tests on the plates of even thicknesses. Also, as follows, the amount of upsetting is considerably less. There is little or no upset or reinforcement on the top or flush surfaces, most of the upsetting taking place on the bottom side of the 1-mm. sheet. Actually the upsetting has the effect of forming a small fillet between the underneath surface of the 1-mm. sheet and the weld face of the 3-mm. sheet.

Figure 14 is a microphotograph of the 3-mm. stock and shows it to be a medium quality, low-carbon steel consisting of medium fine-grained ferrite. High magnification also showed very small spheroids of cementite. Figure 15 is a microphotograph of the 1-mm. stock and shows it to be a rather dirty coarse-grained annealed sheet. The top of the microphotograph is one of the surfaces of the sheet. The steel is rather peculiar in that there is massive intergranular cementite in a band near the surface. The center is low carbon but shows occasional cementite. The other surface was similar. Figure 16 shows the weld. The top of the microphotograph includes the re-entrant angle with the 3-mm. sheet on the left and the 1-mm. on the right. At this point, the two kinds of stock appear very similar in carbon content and grain habit after the welding operation and the actual

Table 3—Welding Conditions for Dissimilar Thicknesses, 3 and 1 Mm.

Thickness of sheets.....	1 mm. and 3 mm.	0.039 and 0.103 in.
Width of sheets.....	500 mm.	19.69 in.
Height of burner above sheets.....	6 mm.	0.236 in.
Distance between sheets	3.5 mm.	0.138 in.
Distance of axis of flames:		
from 3-mm. sheet....	0.7 mm.	0.276 in.
from 1-mm. sheet....	2.8 mm.	0.110 in.
Upsetting pressure.....	1.3 kgs./mm.^{2}	1849 lb./sq. in.
Duration of heating....	6 sec.	6 sec.
Oxygen and acetylene pressure at equalizer.	0.25 kgs./cm.^{2}	3.6 lb./sq. in.
Oxygen and acetylene flow.....	20 m.^{3}/hr.	706.2 cu. ft./hr.
Cooling water flow.....	300 l./hr.	79.3 gal./hr.

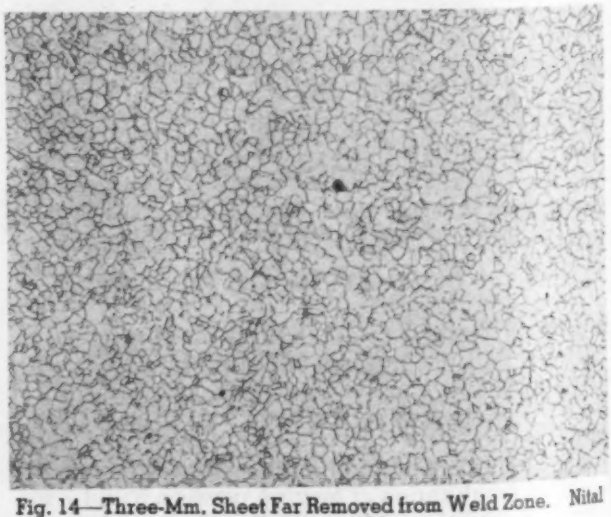

Fig. 14—Three-Mm. Sheet Far Removed from Weld Zone. Nital Etch. × 100

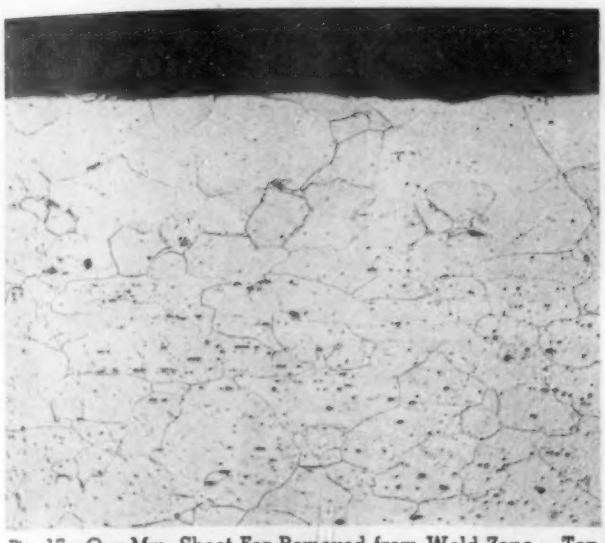

Fig. 15—One-Mm. Sheet Far Removed from Weld Zone. Top of Micrograph Is Surface of Sheet. Nital Etch. × 100

line of weld is indistinguishable. Where the low-carbon interior of the 1-mm. sheet joins the 3-mm. sheet the line is clearly visible, though the union is perfect. The 1-mm. sheet has grown a coarse, clear grain; the 3-mm. sheet a subdivided coarse grain. The weld was also etched in alkaline chromate and showed no evidence of oxygen. As a matter of interest, Figs. 17 and 18 are included to show what happens to the intergranular cementite in the 1-mm. sheet. The microphotograph of Fig. 17 was taken 5 mm. from the weld line and shows that the massive cementite has begun to go into solution. Figure 18 was taken $2^1/_2$ mm. from the weld line and shows that solution of the cementite is complete and diffusion is well advanced.

From the microscopic study, it can be said that the welding has given perfect results. The fusion of the weld faces is complete, the grains having crystallized across the weld line and there is no evidence of oxygen or oxide inclusions in the weld zone resulting from the welding operation.

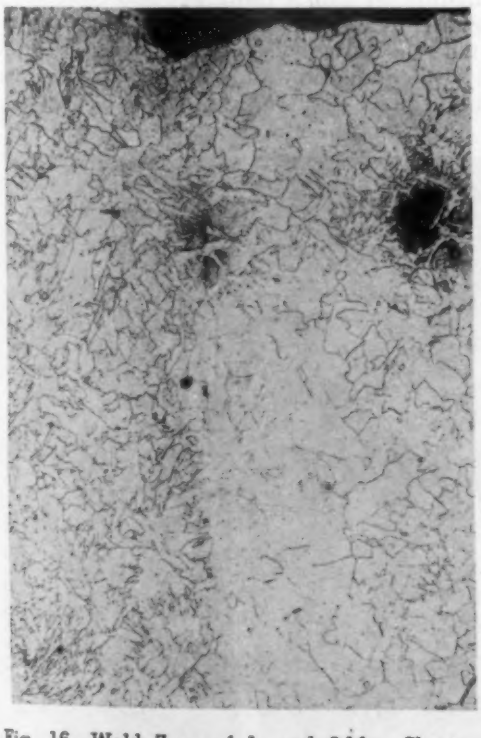

Fig. 16—Weld Zone of 1- and 3-Mm. Sheets. Nital Etch. × 100

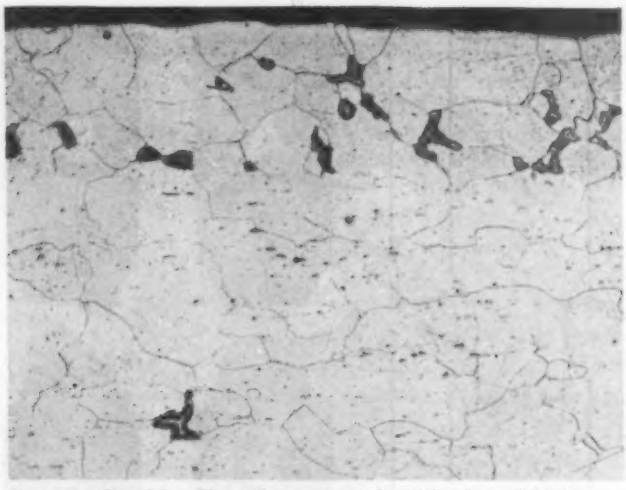

Fig. 17—One-Mm. Sheet Approximately 5 Mm. from Weld Line. Shows Massive Intergranular Cementite Beginning to Dissolve and Diffuse. Nital Etch. × 100

The physical testing of the welds consisted of tension and bending tests. For the tension tests, rectangular coupons were cut from the test pieces measuring 200 x 48 mm. The coupons were then necked down to 30 mm. on both sides at the weld line, as shown on the left of Fig. 19, so that the concentration of stress would be in the weld. Similar coupons were cut from the 1-mm. stock. All the 1-mm. stock coupons, under tension, broke as expected at the narrowest section (see *E* & *F*, Fig. 19) with an average ultimate strength of 51,700 psi. and range of 48,500 to 54,000 psi. and an average yield strength of 34,500 psi. and range of 33,200 and 35,900 psi. The welded coupons all broke outside the weld in the 1-mm. stock, as shown in *A*, *B* and *D*, Fig. 19. The average ultimate tensile strength for the welded coupons was 62,500 psi. with a range of 61,000 to 65,800 psi. and the average yield strength was 46,300 psi. with a range of 44,200 to 50,400 psi. These values are not the actual ultimate and yield strength of the welds because the fractures did not occur at the welds. Actually, the figures in themselves do not mean very much because they were calculated using a cross-sectional area of 30 sq. mm., that is, the cross-sectional area of the 1-mm. stock at the narrowest section of the necked down part of coupons. The thickness at the weld line is actually more than 1 mm. due to the slight upsetting or fillet formed on the underneath

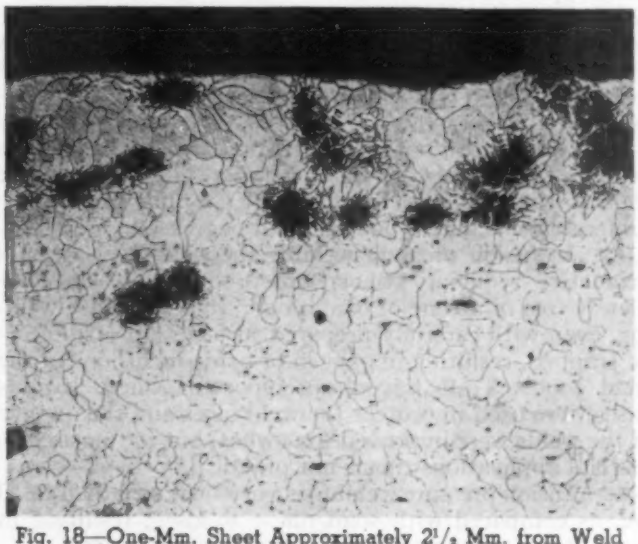

Fig. 18—One-Mm. Sheet Approximately $2^1/_2$ Mm. from Weld Line. Shows That Massive Intergranular Cementite Is Completely Dissolved and Diffusion Is Well Advanced. Nital Etch. × 100

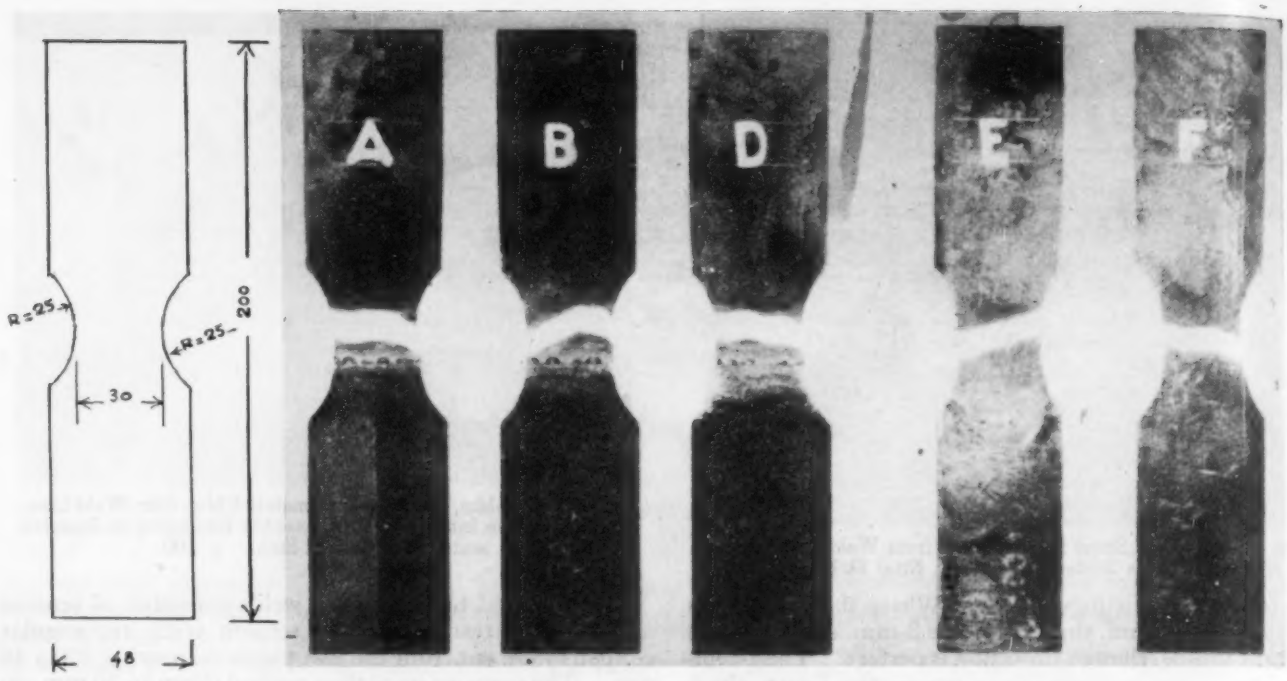

Fig. 19—Tensile Tests of 1- to 3-Mm. Sheet Welds

side of the weld as explained previously. Where the upsetting decreases to zero, the width of section is more than 30 mm. However, the tests do show that the welds in the "as-welded" condition are stronger than the 1-mm. stock.

The welds were also subjected to bend tests, as shown in Fig. 20. Test pieces were bent in both directions and no cracking occurred.

From these tests and the microscopic examination, it is concluded that low-carbon steel sheets or plates of different thicknesses may be butt welded by the fusion pressure process and perfect results obtained both metallurgically and physically.

Summary and Conclusions

1. Fusion pressure welding is a combination of fusion and pressure wherein the weld faces are heated to the melting temperature, then brought together and pressure applied normal to the weld faces. On the other hand, in solid phase pressure welding the weld faces are in contact during the entire process and the pressure is applied during the heating, not after it, and the metal is heated to a high temperature but not to the melting temperature.

2. Great care is not required in preparing the weld faces prior to fusion pressure welding, whereas for solid phase welding the weld faces must be very carefully prepared—preferably machined, polished and degreased.

3. In fusion pressure welding the weld faces are in a protective reducing atmosphere producing welds completely free of a zone of oxidation. In solid phase welding, even with carefully prepared surfaces, air is liable to be trapped, resulting in oxygen or oxide inclusions in the weld zone. Tests have been reported[7] where various gases were used to protect the weld faces and the quality of the welds were improved somewhat, but for most commercial applications this is not practical.

4. Fusion pressure welding is very fast, usually 5 to 10 sec. as compared with solid phase welding, resulting in much lower consumptions of oxygen and acetylene.

5. In fusion pressure welding if the weld looks good the operator knows he has a good weld because he knows that fusion has taken place as he can actually see the weld faces melting, whereas with solid phase welding he cannot see what is going on at the weld faces and although the weld might appear to be satisfactory, the interior of the weld might be poor due to imperfections in the weld faces.

6. Control of fusion pressure process must be placed on duration of heating and therefore factors influencing heat input must be held constant to a high degree of accuracy. Equipment has been developed that will give the degree of control required. The solid phase process can be controlled by the shortening of the pieces due to the upsetting and hence the rate of heat input is not as critical.

7. Because the weld faces in the fusion process are heated mainly by direct radiation and convection from the flames the entire weld faces can be heated very evenly, whereas with the solid phase process the heating is mainly by conduction and a substantial temperature gradient on the weld faces is difficult to eliminate.

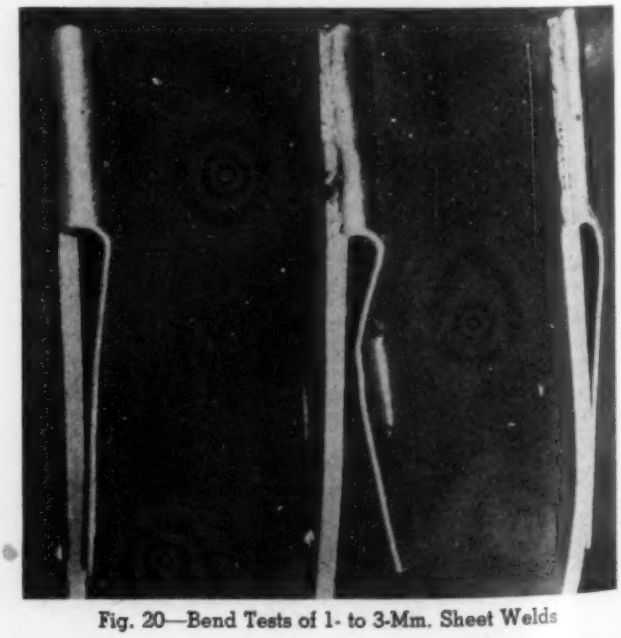

Fig. 20—Bend Tests of 1- to 3-Mm. Sheet Welds

8. The mechanical design of the jigging equipment must be good, as the positioning of the weld components and the even application of the pressure are important.

9. Somewhat lower pressures are used with the fusion pressure process resulting in lower jigging costs.

10. Good welds can be made in light sheet or thin-walled tubing with the fusion pressure process. With solid phase pressure welding, more metal back of the weld faces reaches the plastic temperature making it difficult to prevent buckling. Also because the weld faces in the fusion process are actually melted the upset pressure can be reduced below normal and satisfactory welds still made, whereas the bond in the solid phase process depends largely on the pressure and decreasing this pressure to prevent buckling lowers the quality of the welds considerably.

11. Plates or sheets of dissimilar thicknesses may be welded with the fusion pressure process.

12. The tests conducted so far with the fusion pressure welding process have been confined to joining low-carbon steel sheets of similar and dissimilar thicknesses. The results have been very gratifying. However, until further work is completed on various other types of steel, heavier sections and various shapes, the limitations of the process cannot be stated definitely.

Acknowledgment

The author wishes to express appreciation for the very helpful assistance of Gordon Sproule, Professor of Metallurgical Engineering, McGill University, Montreal, Quebec, in the microscopic study of the welds.

The author also wishes to acknowledge the work carried out by Mr. R. Lagarde of the L'Air Liquide Society Research Laboratory, Paris, France, in the original development of the fusion pressure welding process.

References

[1] Kinzel, A. B., Adams Lecture, "Solid Phase Welding," THE WELDING JOURNAL, 23 (12) 1124–1156 (1944).

[2] Koopman, Kenneth H., "Oxyacetylene Pressure Welding of Some Low-Alloy Steels and Non-Ferrous Alloys," *Ibid.*, 25 (11) 1069–1076 (1946).

[3] Lytle, A. R., "Oxyacetylene Pressure Welding," *Ibid.*, 23 (12) 1045–1056 (1944).

[4] First and Second Progress Reports of the Joint Investigation of Continuous Welded Rails, Engineering Experimental Station, University of Illinois.

[5] Sterrett, Elton, "Pressure Welded Pipe Line," *Weld. Engr.*, 30 (2) 37–39 (1945).

[6] Jones, E. P., "Pressure Welding Overland Pipe Lines," *Petroleum Engr.*, 16, 214–220 (March 1945).

[7] Zambrow, J. L., and Williams, R. D., "Pressure Gas Welding of Alloy Steel Tubing," THE WELDING JOURNAL, 25 (10), Research Suppl., 585-s to 596-s (1946).

[8] Proctor, E. R., "The Application of Pressure Welding to the Manufacture of Aircraft Landing Gear," *Ibid.*, 24 (11) 1011–1015 (1945).

[9] Fine, Leslie, Maak, Charles H., and Ozanich, Anthony R., "Metallurgical Aspects of High Quality Pressure Welded Joints for Landing Gear. Part 1. Influence of Oxygen," *Metal Progress*, 49 (2) 350–355 (February 1946).

[10] Fine, Leslie, Maak, Charles H., and Ozanich, Anthony R., "Metallurgical Aspects of High Quality Pressure Welded Joints for Landing Gear. Part 2. Tests, Set-Up and Inspection," *Ibid.*, 49 (3) 530–536 (March 1946).

[11] Fine, Leslie, "A New Etching Reagent for the Detection of Oxygen Segregations in Steel," *Ibid.*, 49 (1) 108–112 (January 1946).

[12] Hall, A. M., "Metallographic Etchant to Distinguish Oxidation in Steel," *Ibid.*, 50 (1) 92–96 (July 1946).

[13] Fine, Leslie, Maak, Charles H., and Ozanich, Anthony R., "Fundamentals Affecting the Bond in Pressure Welds," THE WELDING JOURNAL, 25 (6) 517–529 (1946).

Current Welding Literature

(Continued from page 35)

Oxygen Cutting, Stainless Steel. Flux-Injection Cutting, G. E. Bellew. Welding Engr., vol. 32, no. 9 (Sept. 1947), pp. 60, 62–63, 74, 76; no. 10 (Oct.), pp. 60–62.

Oxygen Cutting, Stainless Steel. Welding and Flame Cutting Applied to Stainless and Clad Steels, S. F. Danes. Matls. & Methods, vol. 26, no. 4 (Oct. 1947), pp. 102–106.

Petroleum Pipe Lines, Maintenance and Repair. Safety-Weld Coupling—on Pipe-Line Maintenance Work, J. B. Smith. Oil & Gas J., vol. 46, no. 20 (Sept. 20, 1947), pp. 193–194, 240.

Petroleum Pipe Lines, Texas-Illinois. Magnolia's 20-In. Crude Oil Line Longest in 1947, P. Reed. Oil & Gas J., vol. 46, no. 20 (Sept. 20, 1947), pp. 170–173.

Pipe Fittings, Testing. Fatigue Tests of Welding Elbows and Comparable Double-Mitre Bends, A. R. C. Markl. Am Soc. Mech. Engrs.—Trans., vol. 69, no. 8 (Nov. 1947), pp. 869–876 (discussion), 877–879.

Pipe, Lead. How to Weld Lead Pipe, L. S. Bowser. Heating, Piping & Air Conditioning, vol. 19, no. 9 (Sept. 1947), pp. 91–92.

Rails, Welding. Pressure Welding of Rails by Oxy-Acetylene Process, R. W. Torbert. Southern & Southwestern Ry. Club—Proc., vol. 30, no. 4 (July 1947), pp. 29–30, 33–34, 37, (discussion), 37–38, 41.

Shipbuilding. Official Abstract, Final Report of Board to Investigate Design and Methods of Construction of Welded Steel Merchant Vessels. Am. Soc. Naval Engrs.—J., vol. 59, no. 3 (Aug. 1947), pp. 353–355.

Shipbuilding. Repairs to Welded Ship Hulls, E. C. Rechtin. Pac. Mar. Rev., vol. 64, no. 9 (Sept. 1947), pp. 43–46, 106, 108; no. 10 (Oct.), pp. 47–49, 96, 98.

Shipbuilding. Structural Welding Research—Study of War-Built Ships, H. W. Hiemke. Western Metals, vol. 5, no. 7 (July 1947), pp. 22–28.

Shipbuilding. Welded Merchant Ship Fractures. Mar. Eng. & Shipg. Rev., vol. 52, no. 9 (Sept. 1947), pp. 67–68.

Steel Castings. Effect of Silicon on Properties of Cast Carbon and Carbon-Molybdenum Steels, N. A. Ziegler, W. L. Meinhart and J. R. Goldsmith. Am. Soc. Metals—Preprint no. 29 (for meeting Oct. 18–24, 1947), 30 pp.

Steel Hardening, Oxy-Gas Process. New Surface Hardener Combines Precision and Speed. Iron Age, vol. 160, no. 15 (Oct. 9, 1947), p. 84.

Steel Heat Treatment. Effect of Stabilizing and Stress Relief Heat Treatment on Welded 18–8 Stainless Steel, W. G. Hubbell. Aircraft Eng., vol. 19, no. 221 (July 1947), pp. 225–228.

Steel Heat Treatment, Quenching. Soluble Oil in Flame Hardening Operations, S. Smith. Iron & Steel Engr., vol. 24, no. 10 (Oct. 1947), pp. 59–63.

Steel Testing, Stresses. Development of Cleavage Fractures in Mild Steels, A. B. Bagsar. Am. Soc. Mech. Engrs.—Advance Paper no. 47—A-75 (for meeting Dec. 1–5, 1947), 36 pp., 7 supp. sheets.

Washing Machines, Manufacture. Modern Streamlined Washing Machines Add to Canada's Expanding Exports, J. Row. Can. Machy., vol. 58, no. 9 (Sept. 1947), pp. 107–111, 228–229.

Welded Steel Structures. Manual of Design for Arc Welded Steel Structures. Compiled by L. Grover. Air Reduction Sales Co., N. Y. (Mar. 1946), 281 pp., illus., diagrs., charts, tables, $2.00.

Welders, Training. Engineering Students Learn Welding, R. C. Wiley. Welding Engr., vol. 32, no. 11 (Nov. 1947), pp. 60, 62.

Welding. How Pressure Welding Works. Eng. & Min. J., vol. 148, no. 9 (Sept. 1947), p. 77.

Welding. Sir William J. Larke Medal Competition, Prizewinning Papers. Institute of Welding, London, S.W.1, 1946. 156 pp., illus., diagrs., charts, tables, 12s. 6d.

Welds, X-Ray Analysis. Inspection of Pipe Line Welding by Radiographic Methods, W. W. Offner. Oil & Gas J , vol. 46, no. 20 (Sept. 20, 1947), pp. 180–181.

Welded Fabrication*

By J. R. Stitt†

IN THE fabrication of weldments by the metal arc-welding process, shrinkage occurs in all directions in the weld metal and the portion of the plate which has been heated sufficiently to cause upsetting. Therefore, various stress patterns are established in the weldment while it is cooling and after it has cooled down to room temperature. These patterns will vary with: (1) the geometry of the weldment, (2) the type of electrode, (3) the type of steel, (4) the pass sequence, (5) the welding sequence, (6) the welding procedure, (7) the preheat and interpass temperature, etc. Stress patterns,

* Presented at Twenty-Eighth Annual Meeting, A.W.S., Chicago, Ill., week of Oct. 19, 1947.
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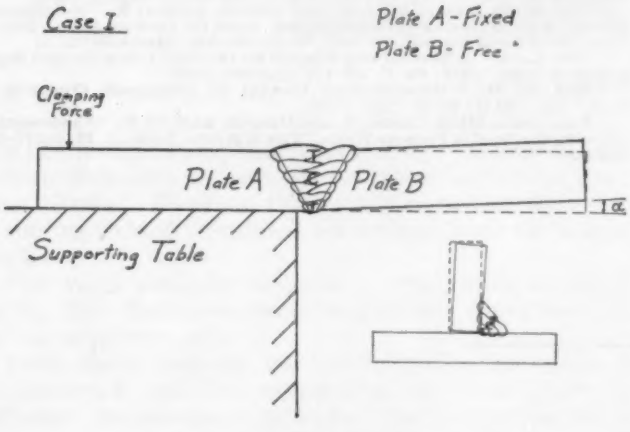


Fig. 1

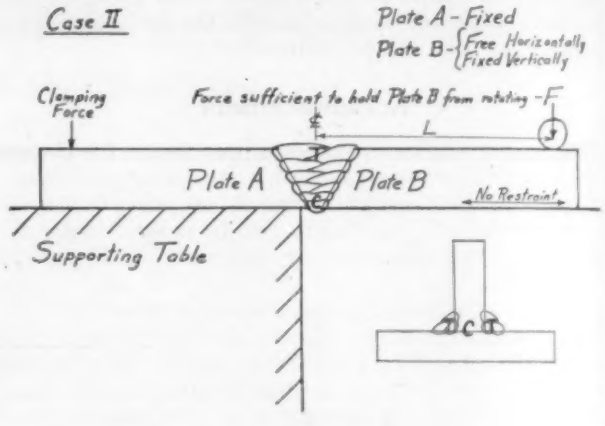
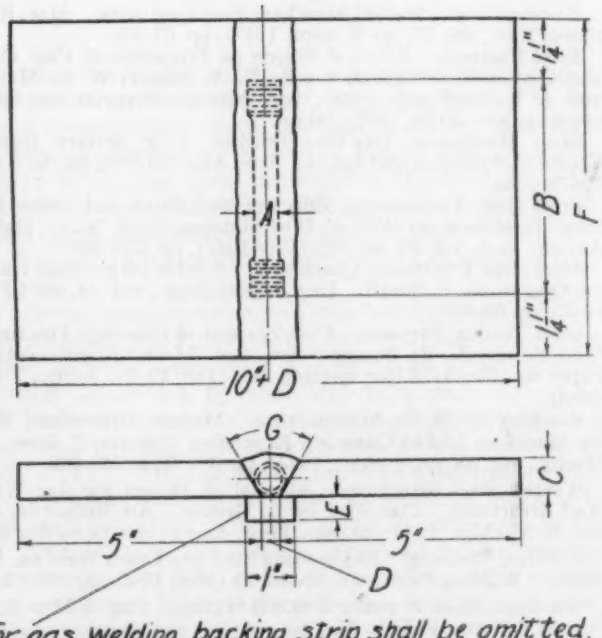


Fig. 3



For gas welding, backing strip shall be omitted. Dotted lines show position from which specimen shall be machined.

Fig. 2

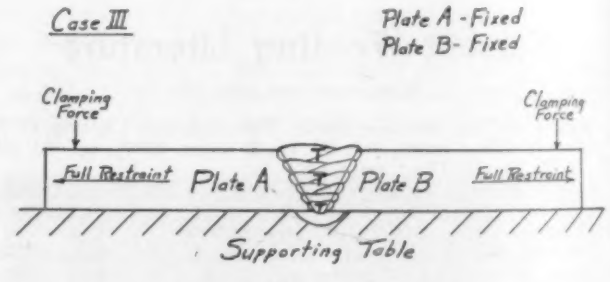


Fig. 4

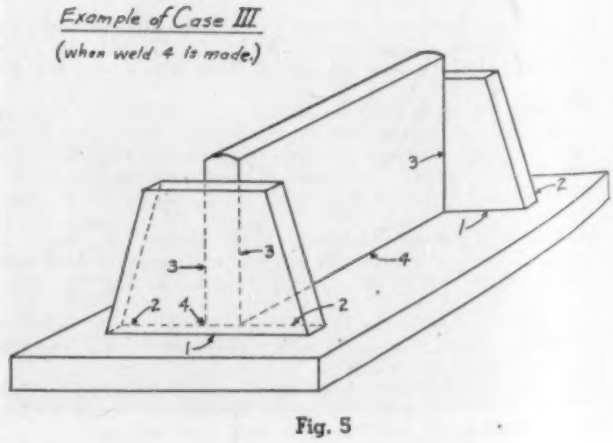


Fig. 5

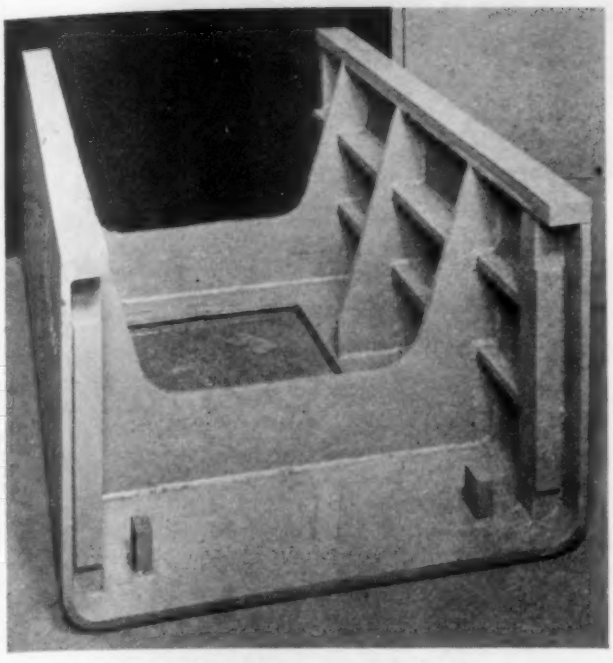


Fig. 6—Weldment for Broaching Machine

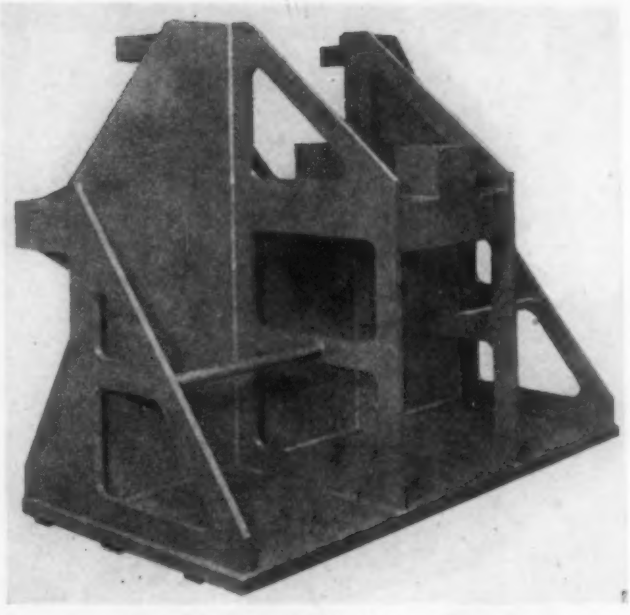


Fig. 8—Weldment for Machining Fixture

therefore, are very complex and difficult to understand. The two things that we can be certain of are (1) that the weldment has considerable residual stresses in it in the "as-welded" condition, and (2) that the forces across any plane which is passed through the weldment are balanced if no external forces are present.

For the remainder of this paper I have chosen to discuss only those stresses which are found transverse to fillet and grooved welds. In analyzing these stresses and the resulting stress patterns, I have found it helpful to classify the joints into three groups according to the restraint on the joint.

In Case I (Fig. 1) Plate A is fully fixed in all directions and Plate B is free to move as dictated by the shrinkage stresses in the weld and base metals. Plate B will rotate through the angle alpha to the new position indicated and the stress pattern in the weld will be tension, compression and tension as pointed out by the letters *T*, *C*, *T* on the end view of the joint.[1] Similarly, in the multiple-layered fillet weld sketched in lower right of Fig. 1, where one plate is free to move, rotation will take place and the stress pattern through the weld throat will again be *T*,*C*,*T*. Figure 2 is an example of a welded joint which can be classified under Case I.

Case II is shown in Fig. 3. Here the stress pattern through the weld has changed to *T*, *C* while the external force *F* is applied to Plate B. A moment therefore exists in the weld as long as force *F* is applied to Plate B. This moment in the weld is equal to *F* x *L*. The sketch in the lower right of Fig. 3 is a special case of Case II in that no external force *F* is required to produce compression at the root of the weld and tension in the last passes of weld metal. Case II is also easily obtainable without external force by welding the girth weld when two pieces of small diameter pipes are butted together.

Case III (Fig. 4) is a theoretical case and fortunately

Fig. 7—Weldment for Machining Fixture

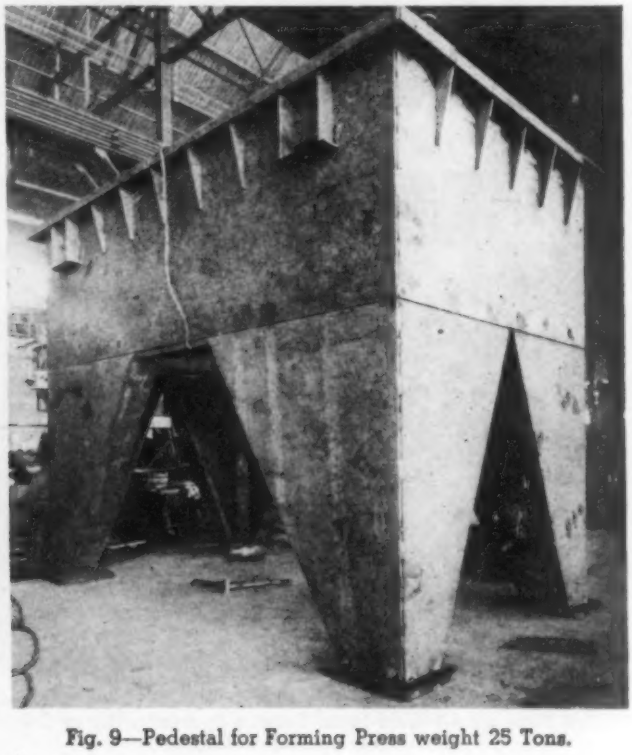


Fig. 9—Pedestal for Forming Press weight 25 Tons.

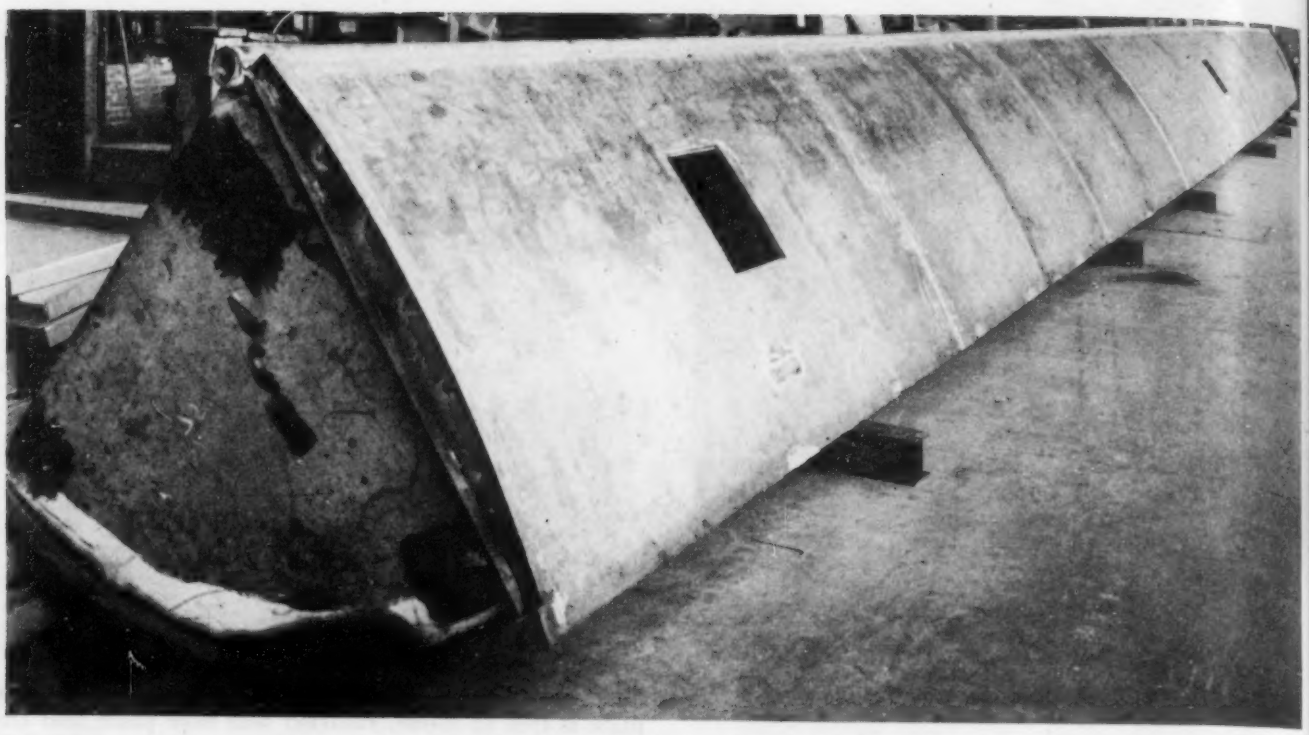


Fig. 10—Drum Gate for Kent Lake Dam

90 Ft. Long Shaft 4 In. Diam. Stainless Steel. Exposed Face—Nickel Clad. Balance—Low-Carbon Steel.

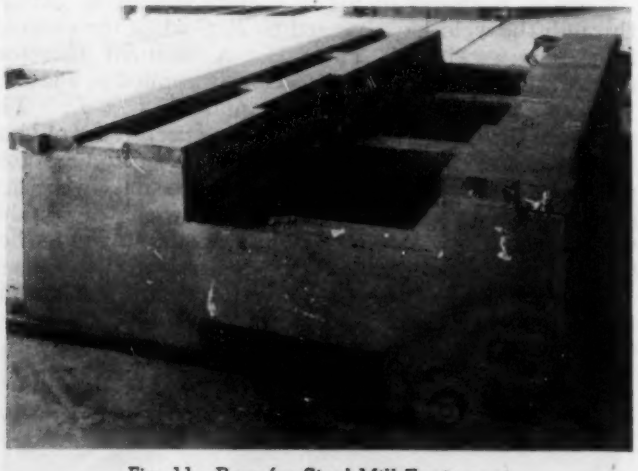


Fig. 11—Base for Steel Mill Equipment

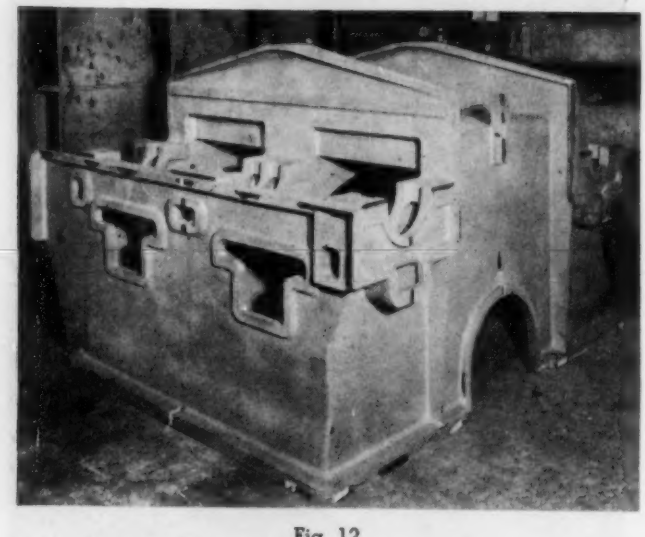


Fig. 12
Test Plate for All-Weld-Metal Tension Specimen C-1 or C-4
Gear Case for Marine Engine

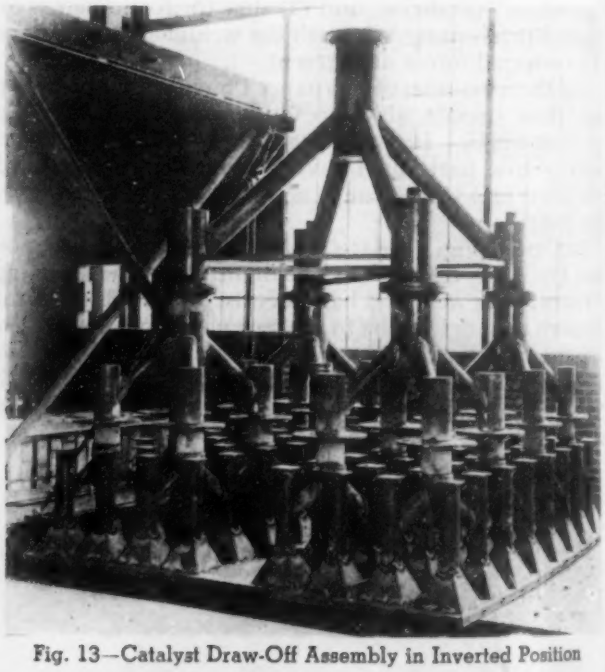


Fig. 13—Catalyst Draw-Off Assembly in Inverted Position

is seldom obtained in practice. Here only tension exists in the weld metal. The Army "H" Plate used during the World War II to qualify welding electrodes and procedures was an attempt to produce the conditions specified in Case III. The weldment pictured in Fig. 5 (at the time weld No. 4 is made) is another attempt to produce the conditions specified in Case III. Both the H Plate and this weldment are combinations of Case II and Case III.

Experience has shown that welds made in restrained joints which resemble Case III often crack. Had the weldment, Fig. 5, been made with welds 4, 2, 1 and 3 completed in that order, each joint would more nearly approach Case II and the welds would be less likely to crack. The butt weld at the bottom of Fig. 6 is another example of either Case II or Case III depending upon

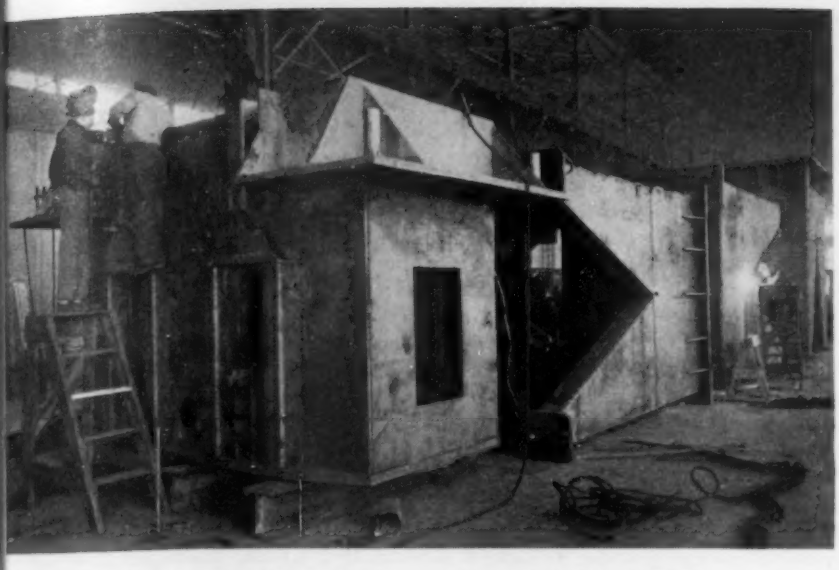


Fig. 14—Press Crown-Foreground Press Pedestals on Right

when this weld is made. If the two formed plates are welded together with a double Vee grooved butt weld before the vertical plates are inserted, the joint is classified as Case II. However, if the two bent plates are first welded to the vertical plates and then the grooved butt weld is made, the joint then should be classified as Case III.

Figure 7 and 8 are two views of a weldment which should be welded in a manner so that the restraint of the various joints will approach the conditions of Case II and be as far as possible from the conditions of Case III.

Figures 9 to 14 are typical of the welding done at the the North Plant of The R. C. Mahon Co., Detroit, Mich., and have been fabricated by taking the above principles into consideration.

1. See article, "Factors Affecting Residual Stresses in Welds" by C. T. Gayley and J. G. Willis pp. 303-s to 306-s THE WELDING JOURNAL (Research Supplement Aug. 1940.)

Welding a Roto-Clone Impeller

By Harrington Powers*

SOME historians credit the invention of the wheel as the act that started civilization rolling. Indeed, it would be hard to imagine our life without the gear, circular saw, pulley, fan and other variations of the wheel. But a group of welders in American Air Filter Company's shops think life for them would have been a lot simpler had one variation of the wheel—the Roto-Clone impeller—remained in the realm of the undiscovered.

The Roto-Clone is a combined exhauster and dust col-

* Welding Supervisor, American Air Filter Co., Inc., Louisville, Ky.

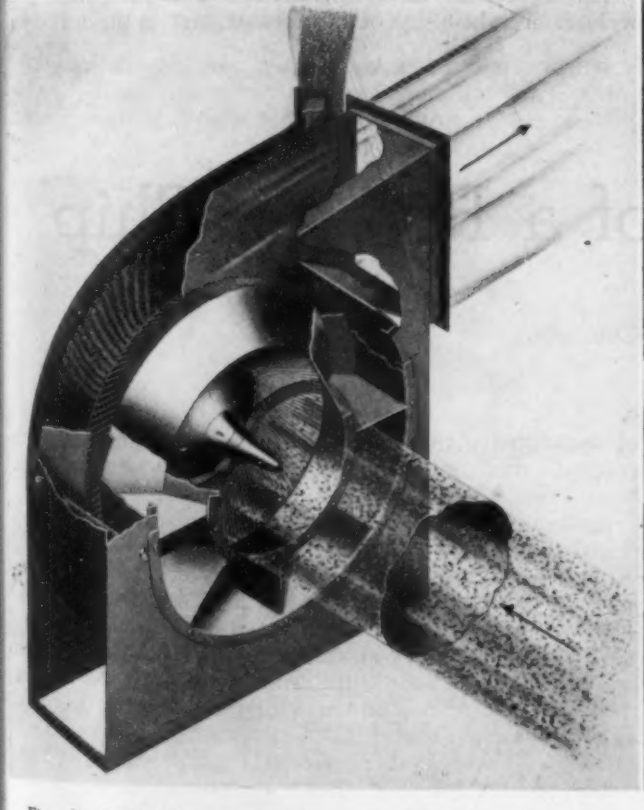


Fig. 1—A Cut-Away Illustration Showing the Operating Principle of the Type F Roto-Clone Dust Collector

Although the impeller pictured here is slightly different from the one discussed in Fig. 2, the operating principle is the same.

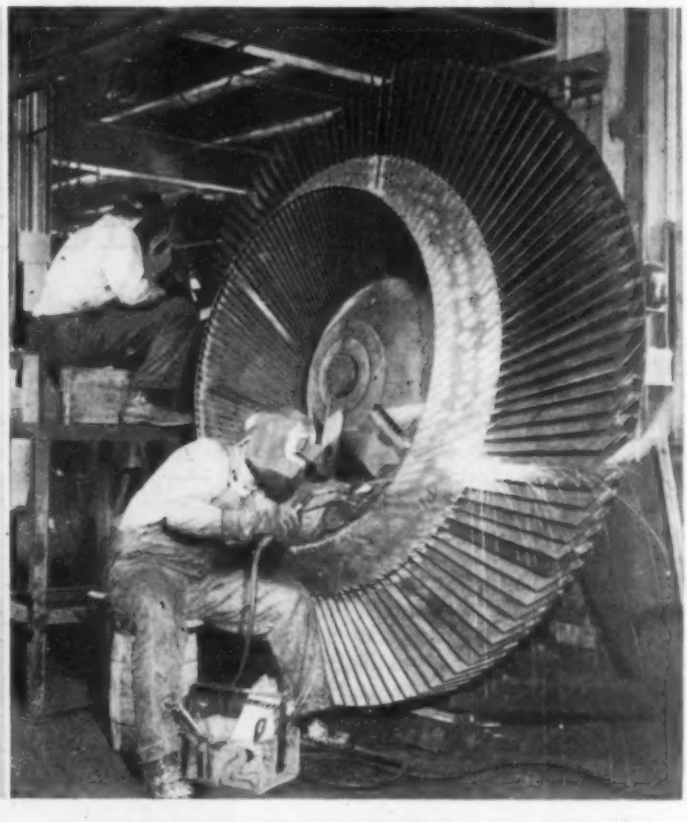


Fig. 2—Welders Near the End of an Arduous Task of Fabricating a Roto-Clone Impeller

In the upper left a man is running a continuous hard-surfacing bead along the reinforced base of the blade. The welder in the center is welding the cone ring to the blades using the block skip method.

lector used principally for controlling process dust. The turbine-like impeller, made of low-carbon steel, the only moving part, consists of a large number of specially shaped blades attached radially to a laminated disk base. Rotation of the impeller creates the necessary suction to draw in the dust-laden air, separate the dust and expel the cleaned air.

The heavier dust particles impinge on the base of the impeller and the lighter particles are precipitated on the advancing surfaces of the blades. Both light and heavy particles move out by centrifugal force to converge at a point on the outer edge of the impeller. The paths of the lighter particles intersect at this point due to the angle of the blade.

Directly opposite this point of concentration is a narrow annular opening through which the dust passes into a surrounding dust chamber. It then passes into a concentrator which is mounted adjacent to the Roto-Clone. In the concentrator, the dust is segregated from the secondary air and discharged. The secondary air is returned to the Roto-Clone inlet. The cleaned air passes into the scroll from which it is exhausted outdoors or returned to the workrooms through filter after-cleaners if conditions permit recirculation.

Fabrication of the Type F impeller pictured above requires no less than 750 carefully executed welds. It is of the same basic design and principle as the first impeller built 14 years ago, but several variations have been made to adapt it to different applications. In practically every instance, the charge has involved more welding in more constricted areas.

The base of the 45-in. design No. 2 impeller (45 in. is the diameter of the air intake duct) is composed of five steel disks graduated in size from 101 to 48 in. in diameter. These plates are punched and chambered to match and then assembled to a machined flange cast hub that is drilled and tapped for cap screws which secure the plates to the hub. The blades are 13-gage steel with a $^{9}/_{16}$-in. flange at 45° to the base. A stiffener angle of the same gage, 2 in. wide and the length of the blade, is spot welded to the flanged part of the blade. Then this assembly is punched, chambered and riveted to the disk assembly.

The cone ring, which spaces and secures the free edge of the blades, is 10-gage steel, rolled to shape, welded and held in position by a specially designed jig. It is then tack welded to the blades with two $^{3}/_{4}$-in. tacks on each blade, one on each edge of the cone ring, and the jig removed to give access for welding. Next the cone ring is welded to the blades by making a sufficient number of intermittent welds using the block skip method. No blades are completed in succession. The general procedure is to make one weld on a blade, then skip to the next blade and make one weld in a different section until all blades are welded at all required sections. This procedure holds distortion to a minimum which is highly important since the over-all tolerances of the entire structure are so small.

In welding the cone ring to the blade assembly, it is necessary to insert the welding rod through openings measuring only as small as $^{7}/_{16}$ in. to depths as great as 17 in. in order to make continuous welds between the blade and the cone ring. Special insulated holders and fixtures had to be designed to accomplish this.

In service these impellers are frequently subjected to abrasive dust, such as cast iron dust and fly ash, moving at high velocities so that it is necessary to provide a coating of abrasive-resistant metal at these points of greatest wear, to increase impeller life. This is accomplished by laying a bead of abrasive-resisting material along the line of contact between the blades and the base. This operation also involves welding in restricted spaces, with clearances as close as $^{3}/_{8}$ in. and depths as great as 22 in.

After carefully balancing the assembled impeller, the welders breathe a sigh of relief—and start on the next one.

Structural Failure of a Riveted Ship*

By E. M. MacCutcheon†

THE *Oakey L. Alexander* was carrying a load of coal from Norfolk, Va., to Portland, Me. A severe storm lashed the Atlantic coast. The heavy seas caused distress to shipping and was too much for the 31-yr.-old ship. Two huge waves boarded the ship from the starboard quarter, washed overboard the port lifeboat, damaged the starboard lifeboat and the boat deck, besides bashing in the oak doors in the deck house. The load of the seas was too heavy. The bow broke off. Her captain grounded her on the rocky coast near Portland, Me.

When the seas had calmed the ship was boarded to investigate the structural failure and compare it with structural failures of welded ships.

During the last 4 years, the problem of structural failures in welded merchant ships was the subject of an intensive investigation. Studies were made of all phases of ship construction procedures and a thorough research program was carried out in an attempt to discover the basic cause of hull fractures.

Some of the more common questions that have been asked concern the difference in the relative performance of ships, constructed by means of riveting or welding. There are some facts which throw light on this difference. The following data form the basis for a partial answer to the question: "Were similar difficulties experienced on riveted ships?" Structural failures are not unknown on riveted ships. Such famous ships as the *Leviathan* and *Majestic* cracked their main decks. In other cases, such as the *Oklahoma* and *Mielero*, the ships broke in two.

These cases are well known in marine circles but the numerous lesser fractures have gone unheralded and without record. Attempts to compile statistics based on such minor failures are thwarted by the lack of evidence. On the other hand, for the last 4 years, the structural-failure data on welded ships were kept in a single central record where they were tabulated and analyzed.

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* Reprinted from May 1947 issue Proceedings of the *Merchant Marine Council*.

† Naval Architect, U. S. Coast Guard.

Fig. 1—Damaged Freighter *Oakey L. Alexander* Grounded at Cape Elizabeth, Me.

During the last war, great numbers of nearly identical welded ships were constructed. Upon the basis of the service records of these similar structures, it was possible to prepare statistical studies. No similar volume of production of riveted ships ever took place. Even the shipbuilding program of Hog Island ships during World War I did not approach the production volume of Liberty ships and T-2 tankers during World War II. The large volume of production of welded ships and the broad survey of structural failures made during the last 4 years permitted a complete statistical analysis which was presented in the final report of the Board to Investigate the Design and Methods of Construction of Welded Steel Merchant Vessels. Since similar records are not available with respect to riveted ships, the exact answer to the question of their relative performance will never be obtained.

Fig. 2—Starboard Side Looking Forward at Edge of Curled-up Deck Plating. The Cleavage Fracture Turns to Shear in the Vicinity of Riveted Seam and Then Back to Cleavage Beyond the Seam

Even before the *Oakey L. Alexander* broke in two, many people asked the question: "Were the structural failures of welded ships similar to those which occurred on riveted ships?" This question could not be answered for a long time because few facts were available for detail study or ready comparison.

The many investigations made on the structural failures of welded ships, broadened the knowledge of fracture characteristics of steel plates and of typically sensitive design features.

When the *Oakey L. Alexander* was boarded by structural experts, they applied the knowledge gained in 4 years of investigation and analysis of welded-ship structural failures. It was possible to survey this ship and compare the findings with the results of investigations of other ship failures. All the phases of the hull structural failure were carefully photographed, sketched and measured. Various samples were removed and forwarded to the National Bureau of Standards for analysis. The final results of this survey will not be available for many months. The general observations made at the survey are very interesting and will in part answer the question quoted above.

The fractures were found to have started at the square corners of the hatches. In addition to the main fractures which broke the ship in two, two minor fractures were found at other hatch corners. These fractures, however, did not continue to spread.

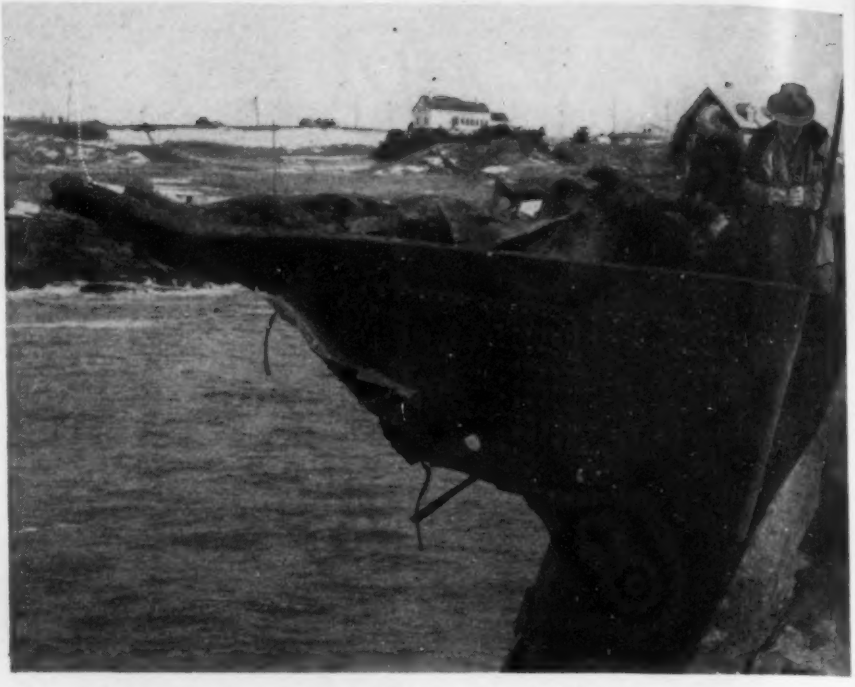

Fig. 3—Coaming of No. 4 Hatch, Starboard Side Looking Outboard, Showing the Main Deck Curled Up Under the Force of Damage

The fracture of the plates was classified as "cleavage." The term cleavage is applied to a crystalline-appearing fracture which is square to the plate surface, exhibits little reduction in thickness or stretching of the material, and which usually has a discernible herringbone pattern pointing toward the starting point of the fracture.

In the way of the starboard deck seam and at certain other locations, it was found that the mode of separation changed from "cleavage" to "shear." A "shear" fracture is silky in appearance, occurs at 45° to the plate surface and is usually accompanied by considerable stretching of the plate. Such fractures were rarely found in the welded ship failures except where a fracture terminated. In this ship, it would appear that the fractures had run from the hatch corners to the riveted seams where a slight pause took place and the fracture changed to "shear." The pause was only temporary, however, as the load on the riveted seams was more than the plating could stand and ultimate failure of the entire hull resulted.

All characteristics of the welded steel ship failures were present. Certainly, it can be said that the structural failures of the two types of ship are essentially the same. The presence of the riveted seams undoubtedly arrested the spread of cracks in numerous cases of riveted ship failures. It is likely that this resistance to the continuation of cracks is the one real difference between the two types of structures. Cracking of one or two plates is not spectacular and would not be expected to attract broad interest. Certainly, the modes of fracture are not fundamentally different and it is likely that the more illusive features attributed to the riveted structure are due to nothing more than lack of detailed facts regarding structural failures in the riveted hulls.

1947 BOUND VOLUME

1947 Bound Volume of The Welding Journal containing the 12 issues of The Welding Journal for the year from January to and including December. Bound in imitation black leather covers. Limited supply. Price $12.50. Order through the American Welding Society, 33 West 39th Street, New York 18, N. Y.

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The third section is known as the "Supplement" but it is an integral part of the Journal. It is a fully technical Section, containing the reports and findings of the Welding Research Council, which meets the requirements of engineers and scientists.

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A.W.S. CONSTITUTIONAL AMENDMENT

The following amendment of the Constitution of the AMERICAN WELDING SOCIETY, recommended by the Committee on Constitution and By-Laws and approved by the A.W.S. Board of Directors was voted upon and approved at the Annual Business Meeting of the SOCIETY, in Chicago, on October 24, 1947:

"Article III. Membership—Individuals having the qualifications set forth in the By-Laws of the AMERICAN WELDING SOCIETY are eligible for membership in this SOCIETY.

The purpose of the amendment is to harmonize the Constitution and By-Laws.

A.W.S. By-Law Amendments

By-Law amendments of article II, Section 2, "Honorary Membership," and Article XII, Section 7, "Nominating Committee," submitted with letter ballot to the membership for vote, under date of Sept. 15, 1947, now stand approved and will be incorporated in the By-Laws appearing in the 1948 Year Book.

WELDING HANDBOOK

A third printing of the *1942 Welding Handbook* has just been completed to meet the demand for copies of this book until the Third Edition becomes available in the Fall of 1948. Immediate delivery will be made on all orders at the regular prices of $5.00 per copy to members, $6.00 per copy to nonmembers in the United States and $6.50 per copy elsewhere.

Send check or money order to AMERICAN WELDING SOCIETY, 33 W. 39th St., New York 18, N. Y.

ADDITIONAL ANNUAL MEETING STATISTICS

We have additional information on the 29th National Metal Exposition and Congress recently held in Chicago. The clocked attendance figures during the seven days showed that 55,630 people attended the exposition. Actual registration figures amount to 37,764. There were 45 exhibitors showing at least some welding equipment and the number of exhibitors exclusively devoted to this field total 7½% of those in the show, although they represented about 12.3% of the exhibit space.

IMPORTANCE OF TEMPERATURE CONTROL IN THE FABRICATION OF CLAD STEELS

Clad steels consist of a base of plain carbon or low-alloy steel to which there is bonded a cladding or layer of some metal (usually 10 or 20% of the total thickness) which has the desired corrosion resistance properties. Clad steels are most commonly available in plate form, and may have the corrosion-resistance facing on one or both sides of the plate. They provide excellent surface properties more economically than solid alloys or alloy steels.

In the construction of heavy pressure vessels, clad steel plate containing the proper thickness of suitable alloy surface offers a great saving against costly solid alloy steels. These plates are handled by the fabricator in the same general manner as ordinary carbon steel plates except that special prescribed precautions are necessary to prevent cracks either in metal working or fabrication. The surface alloys usually have different coefficients of expansion and conductivity than the carbon steel base and this must be taken into consideration.

Fabrication steps in the manufacture of pressure vessels generally consist of bending the plate to cylindrical shape, longitudinal seam welding, re-rolling, circumferential seam welding, heat treatment. The greatest danger from defects is in welding these dissimilar metals and if proper precautions are not observed, cracks may be present in the welded joint. The greatest susceptibility to cracking is shown by the plain high-chromium steels (12 to 27% Cr A.I.S.I. types 410, 430, 446). It is imperative that these be preheated to 300° F, minimum, especially in the case of type 410. Preheat to 200° F. is also recommended for the high nickel chromium types of cladding. TEMPILSTIKS° are widely used in industry as a dependable and convenient method of signaling these and other temperatures.

ACRO WELDER APPOINTS MARSH TO ILLINOIS-INDIANA

Appointment of Charles T. Marsh to the position of Sales Representative in the territory of Illinois and Indiana has just been announced by J. T. Collins, President, Acro Welder Mfg. Co., Milwaukee, Wis.

Mr. Marsh brings to Acro Welder a rich background of experience in the resistance welding field. He is an expert on resistance welding application having designed many fixtures and machines for special requirements.

Well known throughout the industry, Mr. Marsh served the past 18 years with the Taylor-Winfield Corp. as sales and service engineer. Prior to this connection, Marsh spent ten years in the resistance welding department of the Highland Park and River Rouge plants of the Ford Motor Co. He is a member of the AMERICAN WELDING SOCIETY. Headquarters for Mr. Marsh have been established at 4022 North Francisco Ave., Chicago, Ill.

SIGHT FEED CATALOG

The latest catalog covering Sight Feed Model "A" Generators is now available on request. Sight Feed Model "A" Generators are for stationary installations by large users of acetylene. Write for "Catalogue Wj," The Sight Feed Generator Co., Richmond, Ind.

ARNOTT WINS DAVID TAYLOR MEDAL

The Society of Naval Architects and Marine Engineers, at their Annual Banquet held on Friday Evening, Nov. 14, 1947, at the Hotel Waldorf-Astoria, awarded the David W. Taylor Medal to Mr. David Arnott. There follows the citation given with this award.

Citation

David Arnott, naval architect, was born at Glasgow on April 1, 1878, and became a citizen of the United States of America in May 1924. His entire life has been devoted since boyhood to his profession.

Graduating in 1894 from the Royal Technical College, Glasgow, he served an apprenticeship at the Fairfield Shipbuilding and Engineering Co., Ltd., leaving that firm in 1901 to accept appointment to a surveyorship in the British Corp. for the Survey and Registry of Shipping.

There he served in both technical and practical capacity at the head office in Glasgow until 1917. During that period the transition took place in the field of naval architecture which saw the radical revision of theory and practice respecting the distribution of material in the ship structure, and marked the end of the influence of the shipwright without technical knowledge upon the naval architect with shipbuilding experience. Those early years saw the birth of the bulk oil carrier, the single decker, the turret decker, and the now essential details of design such as inner bottoms, wide spaced pillaring and the longitudinal system of framing. During this period the great trans-Atlantic passenger vessels were built and the modern concepts of freeboard and subdivision took form. In all these developments he had a part.

Appointed by the British Corp. to be Principal Surveyor in Canada in 1917, he took charge of the survey of the large shipbuilding program undertaken there during World War I.

Following the reorganization of the American Bureau of Shipping and the formation of its close relationship with the British Corp., Mr. Arnott's technical advice and assistance, particularly with respect to loadline application led to his association with the American Bureau of Shipping in 1918 in the capacity of Deputy Chief Surveyor, and later Chief Surveyor and Vice-President. After almost thirty years of continuous service with the American Bureau of Shipping he earned a well-deserved retirement from active duty Aug. 1, 1947, but retains his identity with the Bureau as consultant.

His knowledge of all the technical phases of ship design and construction has led to participation in the work of numerous bodies engaged in scientific and technical development, among which are The Society of Naval Architects and Marine Engineers, on whose Council he serves; the AMERICAN WELDING SOCIETY in which he has served as member and chairman of many committees, as well as its President; the Welding Research Council; the United States Delegation, International Safety of Life at Sea Convention London 1929 as Technical Advisor; the International Load Line Convention London 1930 as United States Delegate; the Institute of Naval Architects and the British Institute of Welding.

In 1941 he was the recipient of the Miller Memorial Medal of the AMERICAN WELDING SOCIETY.

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ship design and construction lies in his rare combination of scientific attainment in the fields of mechanics and materials with his rich experience of the service behavior of ships. He is endowed with that clarity and logic of mind which has enabled him to separate the essential truths from the mass of theories and assumptions which surround the mechanics of ship design and from the conflictions of operating data as well. His courage of conviction and his unique and forceful personality have made him quite naturally the leader of progress in his chosen field. The weight of his position he has constantly used to point the way to more efficient use of materials and simplification of construction. He has fostered the use of welding in ship construction and repair through its years of application as a somewhat makeshift tool of the ship repairer and a short cut accessory of the shipbuilder into that stage where it became the principal and frequently the sole means of joining the ship structure. Late in 1939, unnoticed by many, with his encouragement the final step was taken, i.e., the elimination of the passing member in the joining of sections. This permitted the rapid and efficient erection of completed subassemblies, and their connection when positioned for efficient construction, which eliminated thereby much of the need for skilled work on the ways.

Had this step not been taken, eliminating as it did the need for vast numbers of men physically fit to drive rivets and permitting even women to do some share, it is doubtful whether the demand for our World War II merchant tonnage could have been satisfied in time.

For notable achievement in naval architecture, The Society of Naval Architects and Marine Engineers awards to David Arnott the David W. Taylor Gold Medal.

CHARLES D'W. GIBSON ELECTED TO AIR REDUCTION BOARD OF DIRECTORS

Charles D'W. Gibson vice-president of Air Reduction Co., Inc., was elected a director of the company it was announced recently by C. E. Adams, chairman of the board.

Mr. Gibson, vice-president in charge of sales, joined the company as a salesman in 1919. After successively managing the Richmond, Va., and Detroit, Mich., sales districts, in 1926 he was appointed assistant vice-president and general sales manager. Since 1937 he has been vice-president in charge of sales.

Charles D'W. Gibson

Mr. Gibson is a graduate of Union College and served during World War I, first with the Australian army and later with the 306th Infantry Regiment, A.E.F. He returned to inactive status with the rank of captain. He is a member of the AMERICAN WELDING SOCIETY.

ANNUAL WELDING DAY—ALBERTA WELDING ASSOCIATION

The Alberta Welding Assoc. which has been in operation for 12 years with a membership of 350, including licensed welders, shop owners and distributors of welding equipment, held a Welding Day on Nov. 5, 1947, at Edmonton.

Visitors from many points in Central and Northern Alberta including such points as Lacombe, Lloydminster, Vermillion, Camrose, Grande Prairie, Dawson Creek, Jasper, Edson, Waterways and intermediate points were in attendance. Floor space in the Armory was at a premium, and the theme of the show "For the Advancement of Welding Through Education" was borne out in the sixteen large displays of the latest welding equipment and accessories by local distributors of well-known lines of welding equipment.

A very complete program of demonstrations and lectures kept those in attendance interested throughout the day. Lectures were given by R. Gooderham of the Canadian Standards Association Welding Bureau and J. Spankie, Chief Welding Examiner, Mechanics Branch, Department of Public Works, on "Welding Standards"; by C. W. Carry, President of a construction firm of the same name, on "Welding in Design and Construction of Buildings"; and Randall Walker, president of the Alberta Welding Assoc., on "The Aims and Objects of the Alberta Welding Assoc."

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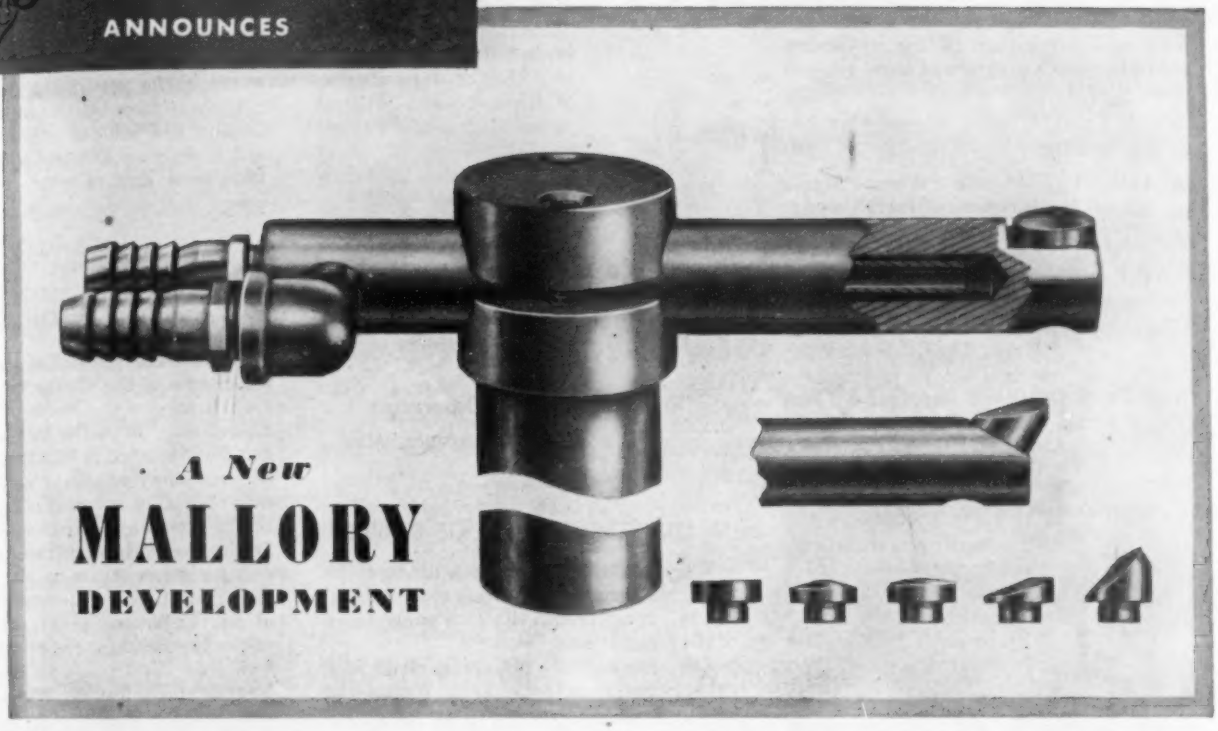
RESISTANCE
WELDING ELECTRODE
HEADQUARTERS
ANNOUNCES



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This combination of holder and electrode, designed and built by Mallory, typifies Mallory leadership in the solving of problems related to the increasing use of Resistance Welding. Mallory is the only supplier of Resistance Welding electrode materials with a completely equipped research laboratory and engineering department specifically devoted to designing and testing improved methods and equipment.

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Mallory Improvements Are At Work Wherever Resistance Welding Is!

WELDING PAPERS

The American Institute of Electrical Engineers is planning two sessions on welding during the winter meeting in Pittsburgh during the last week of January. Members of the AMERICAN WELDING SOCIETY are invited to attend these sessions and participate in the discussion. Below is given a program of these two sessions.

I. Arc Welding

C.P. 1. "Electric Power Supply Problems of Inert Gas Arc Welding," by A. U. Welch, General Electric Co.

C.P. 2. "Electronic Equipment for Submerged Melt Welding Processes," by J. J. Kratz, The Linde Air Products Co.

C.P. 3. "Power Supply for Farm Welders," by A. A. Mathews and G. V. Patterson, Ohio Power Co.

II. Resistance Welding

C.P. 1. Rhoades' subcommittee report on Power Supply for Resistance Welding Machines.

C.P. 2. "Resistance Welding in the Steel Mill," by Mr. Riley, Taylor-Winfield.

C.P. 3. "Various Resistance Welding Systems and Their Effect in the Power Supply," by C. E. Smith.

C.P. 4. "What Is Resistance Welding?" (Speaker from R.W.M.A.)

C.P. 5. "Use of Resistance Welders in Fabrication of Steel" or "Use of Hydramatic, Multipoint and Ultra-Speed Resistance Welders in Fabrication of Sheet Steel," by G. I. F. Theriault.

C.P. 6. "Large Series Capacitor Welding Apparatus," paper by Federal-GE to be investigated by Mr. Deffenbaugh.

C.P. 7. "Postwar Welding of Aluminum."

ELECTRIC WELDING COMMITTEE

C.P. Conference paper.

'A QUARTER CENTURY OF SERVICE"

The Standards Association of Australia takes pleasure in announcing that on Nov. 2, 1947, it celebrated the 25th anniversary of it's foundation.

The passing of the years has seen changes and vicissitudes in the fortunes of the Association but, even through the dark years of the financial depression, the Council of the Association never faltered in its determination to make the S.A.A. a truly effective instrument in the industrial development of Australia.

The Association did not hold special commemorative functions, but prepared a brochure recording the story of achievements in the past quarter century.

It also referred to the Anniversary in the October 1947 issue of its Quarterly Bulletin, and hopes to acknowledge in the January 1948 issue any messages of greeting received.

CALIFORNIA AIR PRODUCTS COMPANY CHANGES NAME

Burdett Oxygen Co. of California is the new name of the California Air Products Co., division of the Burdett Oxygen Co. of Cleveland. Both the newly erected oxygen plant located in Huntington Park, and the new acetylene plant at Los Nietos are now operating at full capacity.

The company also announces that Pat Zeedik, formerly with the Cleveland division for many years in the sales department, will become the new Sales Manager of the California plant. This company not only manufactures oxygen and acetylene, but carries a full line of welding, cutting and safety equipment.

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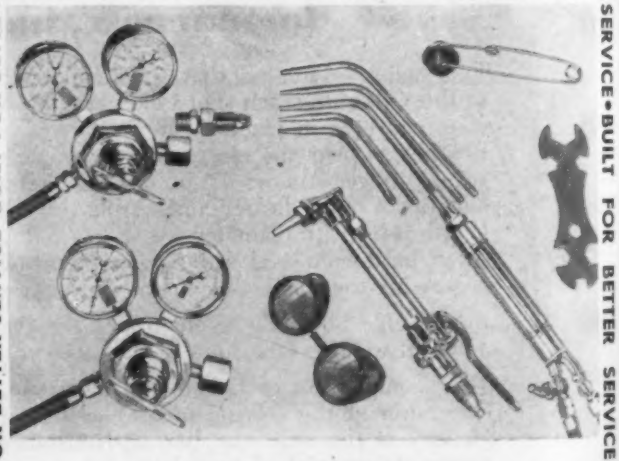

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How the First All-Steel Welded Vise is Made

By H. F. Seymour, President
Columbian Vise & Manufacturing Co.
Cleveland 4, Ohio

WHAT is believed to be the first all-steel vise fabricated by arc welding is the Columbian Work Shop Vise shown in Fig. 1. This vise was redesigned in collaboration with Parsons Engineering Corp., welding specialists, from conventional construction to arc welded steel to achieve superior strength, accuracy and long life.

Basic material used is SAE 1020 hot rolled steel plate, punched and formed to the proper shapes. Fig. 2 shows the component parts. The base plate is ⅜" thick,

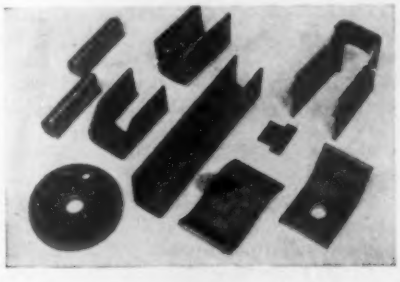

Fig. 2. Component parts of the vise.

the nose piece 5/16" and all others 3/16".

The first fabricating operation is the welding of the front, or sliding, half. The rail, T-blank, front body and jaw are assembled in a jig and tack-welded. In

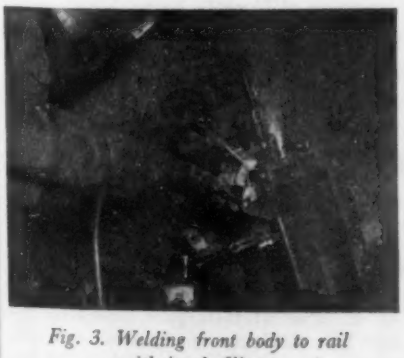

Fig. 3. Welding front body to rail with inside fillets.

this same jig the front body is welded to the rail with inside fillets (see Fig. 3), and the nose piece tacked on.

This front half is then passed to the

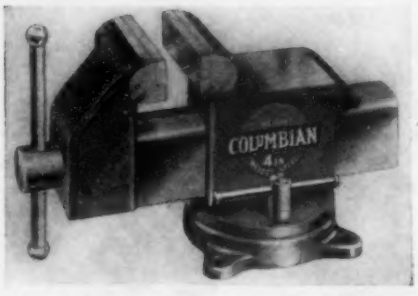

Fig. 1. The Columbian all-steel welded vise.

next welder, who makes the final fillets which join the nose piece and T-blank to the front body. The next operator welds the jaw to the nose piece.

Meanwhile, the rear half of the vise is being assembled in similar manner by another bank of welders. The rear body and swivel base are assembled in a jig and tacked together by the first man. The next man welds these parts with continuous fillets.

The front half and the partially-assembled rear half of the vise are then passed to a welder who fits them together. He inserts the sleeve, or inside guide, in the rear body, slides the rail of the front half through it, and welds the sleeve to the rear body with four 1-inch welds. Fig. 4 shows how the assembly is clamped in the jig. He then tack-welds on the rear anvil.

The vise then goes to the last welding operator, who welds the rear jaw to the anvil and the anvil to the rear body.

The vise assemblies are passed from one operator to the next by means of steel chutes.

Air hammers are used to peen the welds and clean off the spatter, and the welds are then ground smooth. Hardened steel jaw faces are drilled and counter sunk into the jaws. The screw and handle are forged steel and the malleable iron nut is replaceable.

AWS Type E-6030 electrode is used for welding the rear body to the base in

Fig. 4. Raising clamp which held inside sleeve for welding to rear body.

order to get a fillet with exceptionally deep penetration. For all other welds, E-6012 electrode is used.

With 12 set-up men and welders, 1,000 vises are produced a week. Production can be stepped up to 2,500 a week by increasing the force to 22 men.

Fig. 5. Making final welds—anvil to body, and jaw to anvil.

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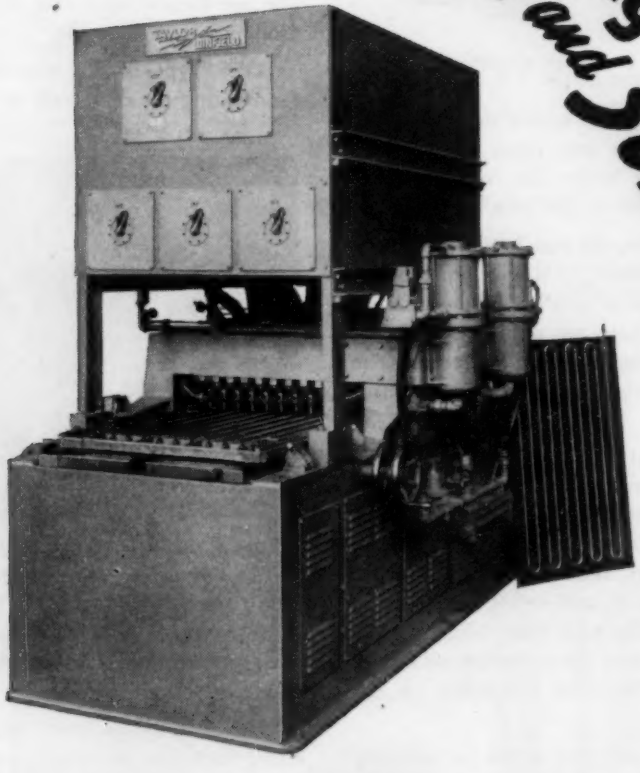

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RESISTANCE WELDERS

CORNELL ESTABLISHES METALLURGICAL COURSE

Cornell University recently announced the establishment of an endowed professorship of metallurgical engineering named for Francis Norwood Bard, owner of the Barco Mfg. Co. of Chicago. Mr. Bard made the formal presentation of a $250,000 fund to endow the professorship at a dinner in his honor.

The university also announced the appointment of Prof. Peter E. Kyle as the first occupant of the chair, and redesignation of the School of Chemical Engineering as the School of Chemical and Metallurgical Engineering to place new emphasis on instruction and research in metallurgical engineering. Professor Kyle is chairman of the Educational Committee of the AMERICAN WELDING SOCIETY.

The developments were disclosed by Dean S. C. Hollister of the College of Engineering, who presided at the dinner.

Presenting the fund to the university, Mr. Bard asserted: "If this professorship can produce one or two outstanding brilliant metallurgists of world-wide recognition a generation, it will have accomplished a worth-while task. Let us hope that it will produce one every few years. We can use them.

"But," he added, "coupled with this search for prepotent minds must go the development of hundreds of finely trained metallurgists capable of serving industry and their country well. Both are important."

President Edmund E. Day, accepting the gift for the university, declared that "an endowed professorship is especially significant in the life of a university because it is a direct investment in men.

"I am confident," he said, "that Professor Kyle and those who follow him in this new chair will fulfill the desires which the donor has expressed. Not only will they themselves undertake metallurgical research of a high order, but they will also train young men of superior scientific promise for the metallurgical industries in this and future generations."

Professor Kyle, first holder of the Bard Professorship, came to Cornell in 1946. A graduate of Cornell, he holds a degree of M.S. in mechanical engineering from Massachusetts Institute of Technology. From 1933 to 1934 he held the James Ward Packard Fellowship at Lehigh University and for the following 12 years was a member of the faculty at M.I.T., where his duties included direction of courses in materials and metals processing.

During the war, Professor Kyle served as a consultant on materials and production methods for the British Air Commission and as a research supervisor for the U. S. War Metallurgy Committee. He has been actively engaged in committee work with the American Society of Mechanical Engineers, the American Foundrymen's Association, the AMERICAN WELDING SOCIETY, the American Society of Testing Materials and the Society for the Promotion of Engineering Education.

Professor Kyle will head a broadened program in metallurgical engineering already organized in the School of Chemical and Metallurgical Engineering. The school will continue to train chemical

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engineers while preparing other students for responsible positions in research, development and administration in the metallurgical industries.

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Composite Forgings, Inc., Detroit 16, Mich., was organized in 1931. At the time of organization, principal products manufactured were electrically butt-welded composite steel die sections and flat die special forgings. In 1942 the company entered the arc weld fabricating field, and at the present time, in addition to its original products, now fabricates special jigs, fixtures, machine bases, etc., by the arc-welding process. This particular department is equipped with accurate acetylene burning equipment, set-up equipment, materials handling equipment, and, of course, arc welding machines.

Resistance Welder Corp., Bay City Mich., was organized in January 1945, and has its main factory located in Bay City, Mich. The company has a complete engineering department and machine shop and assembly facilities, including transformer department, for manufacturing of resistance welding machines. Specialize in custom-built, high-production equipment of all types, that is, spot, flash and seam welders. The company is headed by officers, three of whom have had from 22 to 35 yrs.' experience in the resistance welding industry.

"ENGINEERING PROGRESS SHOW," MAY 11–16, 1948, PHILADELPHIA, PA.

The Engineers' Club of Philadelphia Junior Members are joining with the Franklin Institute of the state of Pennsylvania in sponsoring a second "Engineering Progress Show" on May 11–16, 1948, inclusive. Exhibits will include many items depicting the progress in engineering. The first show held in the spring of 1947 was highly successful, having an attendance record of over 10,000, and booths sold out to exhibitors in advance of the show date.

The show will be held in spacious Franklin Hall in the Franklin Institute of Pennsylvania. In addition to the exhibits, two nationally prominent engineers will deliver lectures in the Franklin auditorium on two evenings during the week.

Exhibitors are now contracting for booth space. The debut of many engineering advancements is expected to be made at this show.

PATTERN FOR GOOD LABOR RELATIONS

PATTERN FOR GOOD LABOR RELATIONS, by Lee H. Hill, publisher and editor of *Electrical World* and publisher of *Electrical Contracting;* formerly vice-president of Allis-Chalmers Mfg. Co. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. Price $3.00.

This extremely practical approach to solution of the labor-relations problem in industry sets up a just and considerate management-employee relations system as the sensible and workable basis for smooth labor relations. It develops the thesis that good labor relations are built on the individual experience of each employee, and shows management how to establish a policy that will make each employee feel he is being squarely dealt with. Taking into account the abuses of privilege which often exist on both sides, the book draws up a realistic pattern of action for management to follow in order to keep the individual employee satisfied and happy, and less prone to collective expressions of dissatisfaction through the union.

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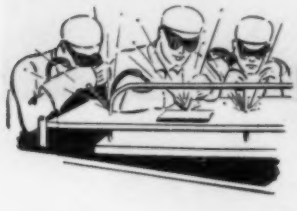

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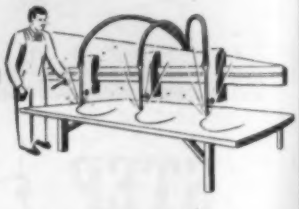

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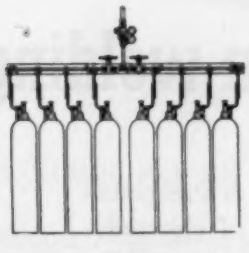

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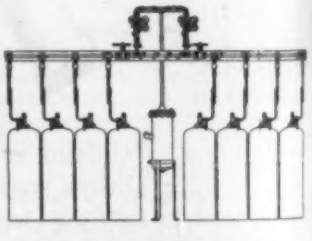

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USE OF WELDING FOR MAKING TOOLS, DIES, AND FIXTURES DISCUSSED BY G-E MEN

Welding is a basic method of fabrication that has a definite place in the construction and maintenance of tools and fixtures, E. H. Girardot of the Punching, Tool, and Die Division of General Electric Co.'s Schenectady Works told delegates attending the recent Boston A.S.T.E. semi-annual meeting.

"Properly applied," he said, "welding will help to save man-hours, materials and production delays."

Speaking with D. W. Puffer of the welding staff of the Company's Thomson Laboratory at Lynn, Mass., on the general subject of "Welding and The Tool Engineer," Mr. Girardot devoted his part of the talk to the tooling phase, while Mr. Puffer talked on the basic welding factors involved.

"Tools, dies and fixtures fabricated by welding compare favorably with those assembled by other methods for several reasons," Mr. Girardot said. "They provide satisfactory accuracy relative to warpage and distortion; they can provide a uniform, pleasing appearance; they are lighter, yet of at least equal strength; they can more readily be changed to suit part revisions; they provide a greater flexibility in design; they can often be produced in less time than those assembled by conventional methods, and they cost less than those assembled in other ways."

Mr. Girardot illustrated each of these points with examples of tools he has designed or with which he has had experience. He also evaluated the various welding processes in regards to the type of tool and fixture work to which they are best adapted.

"Butt welding lends itself readily to the repair of bent drill shanks and broken tangs," he said, "although tangs can also be repaired by the arc-welding method, wherein the worn portion is built up and re-machined. The results, however, are not as satisfactory as those obtained through butt welding."

"Minimum distortion is experienced from resistance welding, since heat is applied to small areas only, with comparatively little effect upon the surrounding metal. Its use, however, is largely limited to those applications not having definite strength requirements, in order to eliminate the necessity of physical tests on sample pieces."

"Gas welding finds many applications in the tool field, such as the hard surfacing of jig feet or wear points on tools, but the arc-welding method is probably the most versatile and has the greatest field of application in both the repair and fabrication of tools," Mr. Girardot said.

After defining a weld and describing the metallurgical characteristics that accompany it, Mr. Puffer told of some of the problems that arise through its use and some of the ways of controlling them. "One of the most basic and important problems, 'he said,' is distortion."

"The first rule for the control of distortion is to have the proper design of the parts to be joined. This is probably the most abused of any of the rules because in many cases the fabricator does not realize the sloppy fit-up and poor joint selection is a more expensive practice than the seemingly costly method of using carefully fitted parts and proper choice of joints.

"The second control consists of suitable clamping of parts to be welded, and the third, using proper welding procedure with particular attention to such items as sequence of welding, rate of heat input and peening. Stress-relief heat treatment after welding provides a fourth control. It may be omitted if control of distortion is not essential, as in the case of fabricated tables, etc., or it may be given after welding and before machining if only normal control is required. In cases of extreme accuracy, the heat treatment may be given after welding and repeated after rough machining."

"Equally important as the reactions of metals to welding and the control of these factors are such questions as whether or not a welding procedure exists or can be developed for the materials in question; can the design be made suitable for welded construction, and is welding more economical than other fabricating processes such as bolting, riveting, etc.," Mr. Puffer continued. "If the answer is yes to all three, welding should be used, but if it is no to any one of them, welding is not the solution for the particular problem at hand," he added.

After summarizing the various processes, their techniques, capabilities and limitations, Mr. Puffer summarized his talk by listing the four points he consid-

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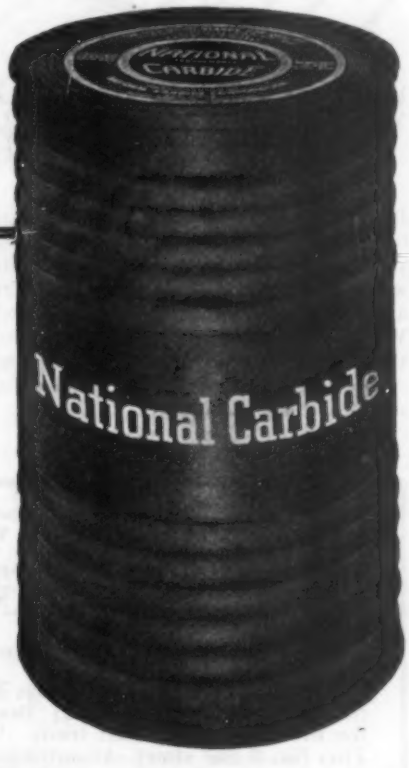

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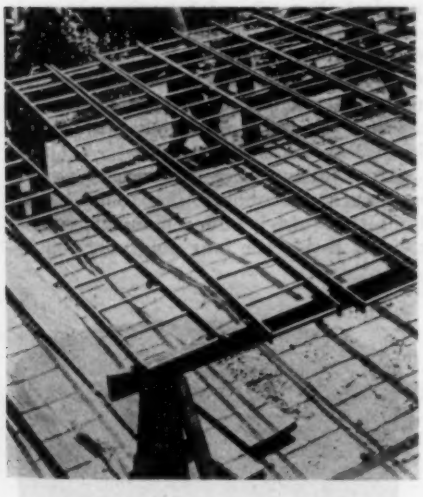
ered most necessary for effective use of welded construction.

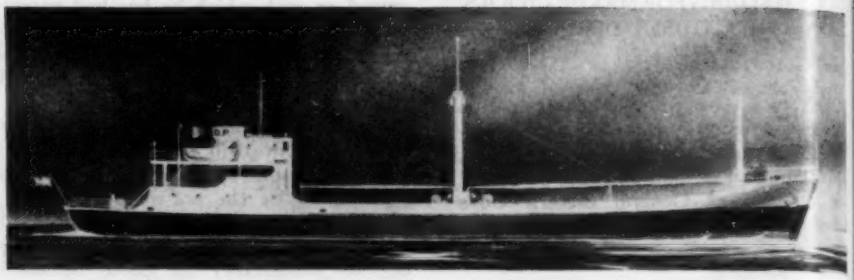
The points were: (1) Parts should be designed for welding, the proper process selected and a suitable procedure determined; (2) suitable equipment must be available; (3) service of reliable, skilled operators is necessary and (4) after the welds are completed they must be judged by qualified personnel as to whether or not they meet the design specifications. This latter point especially is of the utmost importance, particularly if human safety is dependent upon it, he emphasized.

WROUGHT IRON LADDERS

New wrought iron ladders for the 85-ft. deep Main Ave. water tunnel shaft are shown in Cleveland's Woodland Yard. Patterson-Leitch, Cleveland, fabricated them for the City Water Dept. The ladders are to replace wrought iron rungs, set in masonry, that had been in use for 50 to 55 yr. In fabricating the new ladders,



Patterson-Leitch used $2^1/_2$- x $^1/_2$-in. bars for sides and $^7/_8$- x $15^1/_2$-in. rounds, spaced 12 in. apart, for the rungs. The rounds were fitted into holes drilled in the bars and welded in place. The Cleveland Water Dept. specified wrought iron for the new ladder because the old rungs of the same material had resisted corrosion for more than half a century.



ALL WELDED MOTORSHIPS

The artist's rendering of one of the four all-welded steel motorships being built by The Ingalls Shipbuilding Corp. at its shipyard at Pascagoula, Miss., shows the clean and efficient design of the vessels.

The motorships, which will cost approximately $2,700,000, are being built for the Argentine Institute of Trade Promotion and will be operated under the jurisdiction of the Ministry of Public Works of Argentina in river and short coastwise trade, hauling grain and miscellaneous general cargoes.

Each of the vessels will be 232 ft. in length, with a beam of 42 ft. 6 in. and a depth of 15 ft. 6 in., and will displace 1700 tons. Cargo deadweight at 9 ft. draft: 1000 tons.

The motorships will be equipped with twin-screw direct connected Diesel engines with a total of 700 hp. for a speed of 9.5 knots, loaded. On each ship there will be accommodations aft for 22 officers and men, and each ship will have a bale capacity of 70,000 cu. ft. in three holds.

TWO MAINTENANCE AND PRODUCTION WELDING BULLETINS AVAILABLE

Two bulletins issued recently by Eutectic Welding Alloys Corp. are now announced as special reprints to meet demands for them as reference sources by those interested in production and maintenance welding at low base metal heat.

Entitled *Arc Welding Problems Successfully Solved*, one bulletin covers welding cast-iron, low- and high-alloy steels, stainless steel and tool steels to high-carbon steels; welding special manganese parts, elimination of undesirable characteristics and other problems occurring in everyday welding. Twelve production case histories are well presented. Illustration of the various steps make this bulletin worth close study.

The other bulletin, *Another Major Advance in Gas Welding*, describes the use and applications of various new developments in the field of special flux-coated alloys known as EutecRods, for steel, cast-iron, brass and aluminum. Correct welding procedures, together with physical properties, charts and valuable technical data are well outlined and illustrated. Applications discussed include steel, cast iron malleable, bronze, brass, copper.

Both reprints are now available to readers of this magazine on request. Or write direct to the manufacturer, Eutectic Welding Alloys Corp., 40 Worth Street, New York.

HUNT-JORDAN TO REPRESENT PROGRESSIVE IN CHICAGO AREA

Hunt-Jordan Co., with offices at 1147 S. Independence Blvd., Chicago 24, has been organized to handle exclusive representation for resistance welding equipment designed and produced by Progressive Welder Co., Detroit, in Northern Illinois, including Chicago and part of Iowa and Indiana. The company will also handle Knu-Vise toggle clamps in the same territory.

Donald F. Hunt, who heads the new organization, is well known as a welding consultant in this area. He has been associated for some years with Progressive in sales and service capacities, prior to which he was with Stolpher Steel Products Corp., of Milwaukee, as Plant Engineer.

W. H. Jordan, a native of Wilmette, who joins Mr. Hunt in the new organization was for the last two years in charge of standard machine design at Progressive Welder Co., prior to which he was for some $8^1/_2$ yr. associated with Taylor-Winfield in Warren, Ohio.

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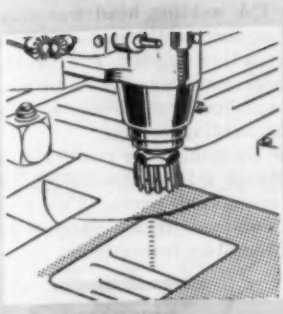

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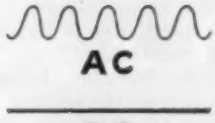
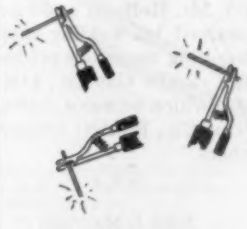


AC OR DC, whichever your machine, you can use "Nicast" for sound, easy welds on cast iron. And "Nicast" is available in the two preferred sizes —1/8" and 5/32" by 14".



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LESS PREPARATION. Another important feature of "Nicast". Most applications require no time-taking preheating or postheating. Welding is simpler, faster.

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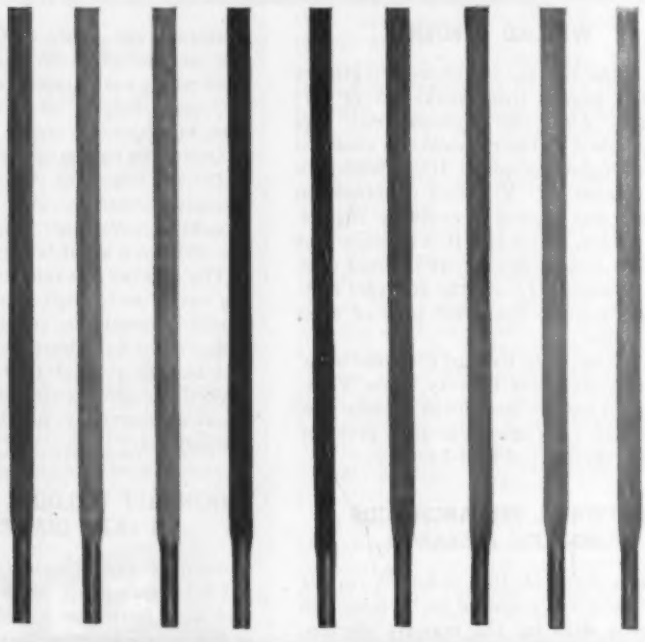

"AW-28"	"AW-4"	"EN-50"	"DH-2"	"FW"	"AC-3"	"PF"	"AC-1"	"AP"
AWS E-10030	AWS E-10012	AWS E-7011	AWS E-6020		AWS E-6013	AWS E-6012	AWS E-6011	AWS E-6010

There is a P&H Electrode in the correct type and size for all mild steel applications as well as for welding stainless and alloy steels and for hard surfacing. Above are shown a few of the complete mild steel group.

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WELDED GIRDER

One of the 12 large 14-ton welded girders from The Ingalls Iron Works Co. of Birmingham, Ala., and Verona, Pa., was photographed in the railyards en route to the Archbishop Stepinac High School in White Plains, N. Y., steel construction on which was started recently by Ingalls.

The girder, which is 4 ft. 4 in. deep and 81 ft. 3 in. long, will support the roof over the auditorium. In all, the contract calls for slightly more than 650 tons of steel from Ingalls.

This school, only Roman Catholic boys' high in Westchester County, New York, was named for the prominent prelate now incarcerated in Yugoslavia as a prisoner of the government of that country.

INDUSTRIAL RESEARCH AIDS SCIENTIFIC RESEARCH

When a total of 13.5 miles of copper strip lengths was required to be joined in continuous strip for the massive electromagnetic coils of Columbia University's new cyclotron, The American Welding & Manufacturing Co., welding fabricators of Warren, Ohio, devised a controlled technique for the flash-butt resistance welding of this difficult material.

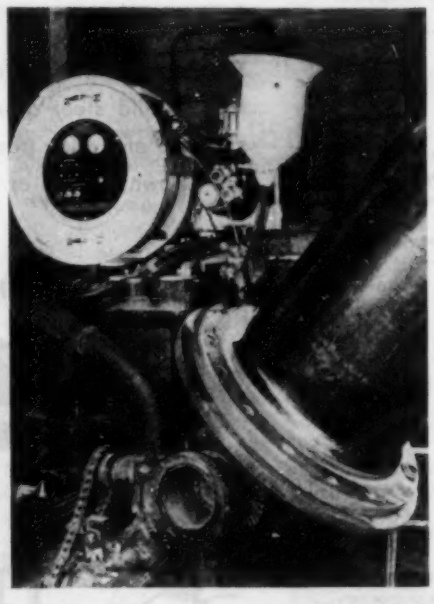
The sample joint displayed by Dr. I. A. Oehler, director of research for American Welding, was made at the conclusion of the welding program, during which 1200 such welds were completed to join 60-ft. x 4-x$^{9}/_{32}$-in. lengths of oxygen-free copper into homogenous strip.

One of the company's resistance welders, a 250-kva. machine equipped with supersensitive controls, was installed in the Brooklyn Navy Yard, where it fed continuous strip to a giant boring mill for coiling.

The specially developed precision welding cycle made high-speed work of what would normally be considered an impossible job for flash-butt welding. Continuous testing proved that the welds possessed the same tensile strength and electrical conductivity as the parent metal throughout.

UNIONMELT WELDING A FLANGE TO AN 18-IN. DIAMETER PIPE

A single operator, using the UNIONMELT equipment shown, can position and weld four pipe and flange assemblies in one hour—the time formerly required to weld one assembly. The UNIONMELT Type CA welding head was mounted on pipe supports with simple sleeve and set-screw adjustments. The welding-head rod-feed motor was driven by compressed air controlled by a solenoid valve actuated by the welding voltage.



The equipment for positioning the pipe and flange was economically constructed from automobile parts. Changes in speed were obtained from a variable drive and an automobile transmission.

OBITUARY

S. E. Hollister

Sydney Ellsworth Hollister was born in Clarion, Pa., May 13, 1893, and passed away at his home, 152 Everett Ave., Newark, Ohio, on July 29, 1947. He leaves a widow, Dorothy E. Nehls Hollister, and three daughters, Mrs. Harold Arnold, June Frances and Sydell Elizabeth.

Mr. Hollister began his career as an auto mechanic in 1918. About 1922, he operated a garage of his own, which he continued until 1932 when he became associated with the Gas Products Co., later known as the National Cylinder Gas Co., as a distributor in Licking and surrounding counties.

During this time, Mr. Hollister had seen great possibilities for welding. He joined the AMERICAN WELDING SOCIETY the latter part of 1940 and devoted his time to studying and promoting welding among his customers. In the last few years his illness prevented him from doing actual welding, but he still maintained his welding shop and advocated welding.

In 1943, Mr. Hollister and his daughter, June, enlarged his welding supply warehouse, handling numerous products of the National Cylinder Gas Co., Lincoln Electric Co. for which he was a dealer, Modern Engineering Co., Burdett Oxygen Co. and many others.

* * *

John J. Manning

John J. Manning, of 182 Forest St., Belleville, N. J., died on October 19th at East Orange Hospital after a brief illness. He was 54 years old.

Mr. Manning was born in Philadelphia in February 1893. He was married to Miss Mary Worrilow. He is survived by Mrs. Manning and three children—namely

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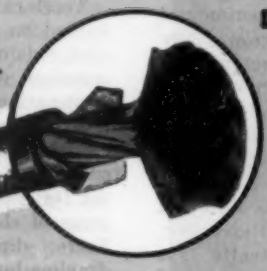

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Mrs. Ransford Crane of Basking Ridge, Mary Jean and John J. Manning, Jr.

Mr. Manning worked for many years in a sales capacity for welding equipment manufacturers at which time he became very much interested in welding rods and their application to ferrous and non-ferrous metals.

In 1938 he established the Industrial School of Welding in Newark, N. J., and in 1940 a branch was opened in Jersey City, N. J. In the two schools of welding he taught hundreds of boys the fundamentals of welding, particularly for many war industries.

In conjunction with the welding schools, Mr. Manning established the Manning Welding and Engineering Co. at 38–42 Ogden St., Newark, wherein specialized welding work was done. During the war he worked on a multitude of projects for the war effort wherein specialized welding work was required. Among a few of the many products were gun cylinders for the Navy, bomb racks, radar equipment, Naval communication system and work on the atom bomb.

In February 1945 Henry S. Lewis, of Union, purchased a half interest in the corporation and shortly thereafter the name of the company was changed to Manning & Lewis Engineering Co.

A new line of work was set up, namely, the fabrication and design of heat exchangers and pressure vessels which involved specialized welding. This work is being carried on at the present time.

Mr. Manning was a member of the AMERICAN WELDING SOCIETY, Newark Athletic Club, Barracuda Club, Advertising Club, Oil-Heat Institute, Whist Club of Newark and the Oranges and the New Jersey Chamber of Commerce. He served in the Marines during the first World War and was a past Commander of a Marine Post for New Jersey.

KNOWLES B. SMITH ACCEPTS EXECUTIVE POSITION WITH DIX ENGINEERING CO., INC.

Knowles B. Smith has resigned as Field Engineer of the Michigan District for Metallizing Engineering Co., Inc., to become Vice-President and General Manager of the Dix Engineering Co., Inc., of 1415 Dix Road, Lincoln Park, Mich.

Mr. Smith has been actively engaged in metallizing and welding engineering for several years. During the war he was an officer in the U. S. Navy attached to the Amphibious Forces of the Atlantic Fleet as a Repair and Salvage Officer for amphibious craft and Diesel engines. Upon his release to inactive duty he resumed his duties with Metallizing Engineering Co., Inc., and remained with that firm until his resignation.

His sales and engineering background will be utilized in his new position by directing the sales and engineering of DIXCO custom-built production metallizing and welding installations as well as directing the contract welding and metallizing phase of the Dix Engineering Co., Inc., activities.

Mr. Smith is a graduate of DePauw University and Oxford University (Eng-

land). He is a member of the Phi Gamma Delta fraternity, Benevolent and Protective Order of Elks and a member of the AMERICAN WELDING SOCIETY (Detroit Section).

WELDING SUPPLY HEAD TO MANAGE NEW AUTO PRODUCTION

John L. Foley, long time proprietor of Buffalo's Welding Supply Center, has been given the responsibility for all production in the United States and Canada of PUBLIX, the new minicar that is only 6 ft. long and prices at from $250 to $495, f.o.b. the assembly plants. Mr. Foley is a member of the AMERICAN WELDING SOCIETY.

"OXYGEN CUTTING OF STEEL AT ELEVATED TEMPERATURES"

The Air Reduction Sales Co. has announced the availability of a new reprint entitled "Oxygen Cutting of Steel at Elevated Temperatures" written by J. F. Kiernan and J. S. Sohn. The article, which originally appeared in THE WELDING JOURNAL, concerns itself with the oxygen cutting of steels at rolling mill temperatures. Also, it contains useful data which have been derived from over 3000 controlled cutting tests.

The 12-page reprint is illustrated with eight photographs and 16 diagrams.

For a copy of this informative reprint write Dept. 1638P, Air Reduction Sales Co., 60 E. 42nd St., New York 17, N. Y., or the Airco sales office nearest you.

DR. DWIGHT F. WINDENBURG DIES; MODEL BASIN PHYSICIST

Dr. Dwight F. Windenburg, chief physicist at the David Taylor Model Basin, died recently in Mount Alto Hospital. He suffered a heart attack in his home, 611 Pickwick Lane, Chevy Chase, Md.

A resident of Washington, D. C., since 1929, Dr. Windenburg was born in Lamont, Iowa, in 1895. He served as radio operator in the Navy from December 1917 to March 1919, and then served as radioman in the Merchant Marine for 15 months.

Dr. Windenburg, a Phi Beta Kappa and Sigma Xi, was a graduate of Cornell College, Iowa, in 1921, and received his masters degree in physics there in 1923. From 1923 to 1929, Dr. Windenburg taught mathematics in California, successively at the University of California, the Polytechnic College of Engineering at Oakland and the Long Beach Junior College. At the last two, he was head of the mathematics department.

Dr. Windenburg went to Washington in 1929 as a physicist with the Experimental Model Basin in the Washington Navy Yard, now known as the gun factory, and has served there in an advisory capacity ever since. At the time of his death he was chief physicist and civilian supervisor of the structural mechanics division of the David Taylor Model Basin.

Dr. Windenburg received his Ph.D. in physics in 1939 from Catholic University, and has served there intermittently as a special lecturer in the graduate school of physics.

A member of the American Society of Mechanical Engineers, Society for Experimental Stress Analysis, the Philosophical Society of Washington, Dr. Windenburg was also vice-president of the Washington chapter of the Instrument Society of America. Dr. Windenburg was also active in the Welding Research Council.

He was a member of the Board of United States Civil Service Examiners for Scientific and Technical Personnel of the Potomac River Naval Command.

Dr. Windenburg is survived by his wife, Mrs. Dorothy Ownby Windenburg; his mother, Mrs. Maude Doak Windenburg, Lamont, Iowa; three brothers, Earle L. Windenburg, Cleveland, Ohio; Ivan Windenburg, Lamont; and Hollis Windenburg Maynard, Iowa, and two sisters, Miss Edna Windenburg, Chicago, and Mrs. Mary Murphy, Wadena, Iowa.

RESISTANCE WELDING BIBLIOGRAPHY

Electric Resistance Welding—A Bibliography of the Literature from January, 1936, to June, 1947, by Harold S. Card, contains titles, authors and publication dates of 646 articles on resistance welding subjects which have been published in 49 technical and industrial magazines during the period indicated in the title. Most of the titles are accompanied by topical synopses indicating the scope and subject matter of the respective articles. Each title is given a key number by which the entire list is indexed under 133 subject headings. Lists of current standards publications and books and booklets are included. Published by Harold S. Card, 22 pages, 8½ x 11; price, $1.00 per copy. On sale by the AMERICAN WELDING SOCIETY.

AMSCO NICKEL-MANGANESE STEEL PLATES

Simple, cost-saving repair or build-up of large wearing areas is made possible with austenitic nickel-manganese steel plates now offered by the American Manganese Steel Division of American Brake Shoe Co., Chicago Heights, Ill.

Torch-cut to desired size or shape and welded on with Amsco nickel-manganese steel rods or electrodes, these impact and arbasion resisting plates provide: (1) Restoration of worn manganese steel or ferrous areas, and (2) Pre-installation protection of ordinary ferrous parts at points subject to wear. An almost unlimited list of applications includes: wearing areas of chutes; jaw crusher cheeks and liners; dipper fronts, sides and doors; dragline bucket bottoms; and surge bins.

Amsco austenitic nickel-manganese steel plates—latest addition to the Amsco Conservation Welding line—are available ¼, ⅜, ½, ⅝, ¾ or 1 in. thick either in the standard 4 x 12 ft. size or cut to order.

CHOICE OF PROPER STAINLESS ELECTRODES

A clear, concise bulletin entitled "What Electrode to Use to Weld a Specified Stainless or Alloy Steel," has been published recently by Arcos Corp., Philadelphia.

The subject is divided into sections for easy reference, and provides information on base metal identification of solid and clad materials, recommended types of electrodes, special considerations involving corrosion, heat or strength properties, as well as suggestions for welding dissimilar metals. Also included is a complete chart of the trade names of stainless alloys as produced by the mills of the country.

Bulletin 1047, which is letter size for filing, is available on request to Arcos Corp., 1515 Locust St., Philadelphia 2, Pa.

Next Annual Meeting
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Oct. 17–22

If you wish to present paper notify National Program Committee at once giving title and short description.

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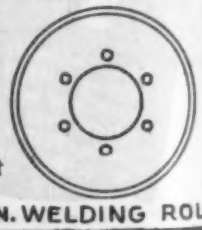
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AIR REDUCTION'S NEW APPARATUS RESEARCH LABORATORY DEVELOPING ADDITIONAL USES FOR INDUSTRIAL GASES

New uses for the industrial gases in the production and finishing of steel products are among the important research activities now being conducted by Air Reduction Co. at its new Apparatus Research Laboratory in Murray Hill, N. J., Charles S. Munson, President, revealed on November 18th.

The injection of industrial gases into molten metals, the oxyacetylene cutting of steel while the metal is still hot and surface-conditioning of stainless steel are examples of the laboratory's developments on which applied research is being pushed in an effort to help industry improve its products, cut production time and reduce operating costs, Mr. Munson said.

"Some 250 engineers, metallurgists, physicists, chemists, technicians and machinists are now engaged in research and development in this laboratory to create new processes and equipment for the industry, in addition to bringing about continual improvements in the oxyacetylene and electric arc methods and apparatus marketed by Airco," he stated.

"Activities at the laboratory," Mr. Munson explained, "are devoted primarily to the development of apparatus, machinery and processes, for fabrication, heat treatment and refining of metals. Among the various equipment and processes designed and studied are those pertaining to all forms of both gas and arc welding, oxygen cutting of metals, handling, controlling and combustion of the atmospheric gases and gas conditioning of metals in the refining and rolling stages.

"Actually," he added, "this work is divided into two general stages—research which consists primarily of studies of basic physical and chemical phenomena underlying industrial production, and developmental engineering which translates the finding of these studies into new commercial apparatus, machinery and processes, or into improvements of existing processes and apparatus.

"Both are equally important, since fundamental research is only of academic interest to mankind until it is put to useful work, while technological progress soon stops unless fed by facts and theory produced by research."

One of the newest, and perhaps most important, of the industrial gas applications on which Airco's researchers are busily at work involves the use of oxygen as an aid in the combustion of fuel in steel melting and the control of hot metal analysis. Test work already conducted in the open hearth indicates that the relatively long period involved in melting down steel scrap may be shortened as much as 40%, but final figures will not be available until further experimental work has been completed.

After 18 months of intensive application in the steel industry, it is obvious that while oxygen is not solving the present steel shortage it has certainly won a high priority in the future thinking of steel plant technologists.

Oxygen Scarfing of Stainless Steel. Operator Is Using Torch to Remove Surface Defects from Slab

Aerial View of Air Reduction's New Apparatus Research Laboratory at Murray Hill, N. J.

NET MONTHLY ADVERTISING RATES

Black and White — *Effective July 11, 1947*

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*Inside Preferred	205	185	170	160

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Considerable experimental work is continuing in extending the use of oxygen in the foundry cupola, and in the Bessemer furnace. A tonnage oxygen plant is now being constructed jointly by Air Reduction, Koppers Co., Inc., and Bethlehem Steel Co. at Johnstown, Pa. When completed it will permit accurate determinations of the problems involved in the manufacture of large volumes of low purity oxygen, and in the use of oxygen for the blast furnace production of iron and ferrous alloys. Other industries, including those connected with ore mining and smelting, copper and brass refining, coal gasification and petroleum production, are following these developments with great interest.

The use of industrial gases for refining metals has advanced rapidly in the past two years. Initial experiments in this field have been made in the steel industry where oxygen is injected into the molten bath of the open hearth to bring about rapid carbon reduction. This results in raising production as much as 25% compared with the slag-metal practice. Already this use of oxygen has become a regular production tool for plants making very low carbon steels. "Flushing" various molten metals with other gases such as nitrogen, helium and argon has been found beneficial in eliminating certain physical defects which might otherwise occur in the solidified product, such as porosity, poor grain structure, brittleness, etc.

The scarfing of stainless steels has become possible through the use of a flux, which has the property of reducing the melting point of the refractory oxides formed, so that the oxidizing action can be generated. The flux is injected into the oxygen stream and passes through the flame, coming into intimate contact with the metal being scarfed.

Less spectacular, but of equal importance to the industries involved, has been the development of inert gas applications, using nitrogen or hydrogen as a base, for the protection of metals during heat treating. In the manufacture of tin plate for the canning industry, in the production of high silicon transformer steels for the electrical industry, and in the making of high-grade alloy steels for the automotive industry, protective atmospheres are playing an increasing role in improving product quality.

Heliwelding is a descriptive term originated by Air Reduction to cover its activities in the increasingly important field of inert-gas-shielded arc welding. Further research on the heliwelding process has demonstrated its remarkable versatility for fabricating most of the ferrous and nonferrous metals and alloys which hitherto have been considered difficult to weld. This has led to the development of an improved water-cooled, heavy-duty manual holder and the recently introduced heavy-duty machine holder and fully automatic apparatus.

These are just some of the processes on which the staff of Air Reduction Co.'s new apparatus research laboratory is now working. There are numerous other applications still in the embryonic stage and as these processes come out of the laboratory they will serve to open additional new fields for the industrial gases. The value of such work with respect to the future sales curve of the compressed gas industry can be effectively demonstrated, when one considers that the application of oxygen in steel-making furnaces alone, would require a three-fold increase in the present oxygen producing capacity of the country, which now stands at the impressive total of 750,000 tons per year.

Physical Description of Air Reduction Co.'s New Apparatus Research Laboratory

Air Reduction Co.'s new Apparatus Research Laboratory is located in Murray Hill, N. J. (near Summit) an area that is gaining considerable reputation as a site for research activities. This site was selected because it combines easy accessibility to some of the best residential districts in New Jersey, as well as metropolitan New York, with the quiet and peace of country life which is conducive to better research work.

The main building is a red brick structure with all-welded steel framework and provides some 78,000 sq. ft. of floor space. In addition, there are two service buildings—an acetylene generator house and a combination boiler room and garage. The buildings, located on the crest of a steep hill overlooking the Passaic River valley, are set back from the main thoroughfare, Mountain Avenue, from which they are shielded by a heavily wooded strip. The approach to the laboratory is by a wide tree-bordered drive overlooking the valley.

Because of the specialized nature of the research work, most of the laboratory space is serviced with outlets carrying high- and low-pressure oxygen, acetylene, nitrogen, city gas, compressed air and 440-v., three-phase and 110-v., single-phase electric current and hot and cold water.

In addition to the main high-ceilinged machine shop and test and assembly area where special experimental machinery and apparatus and prototypes of production equipment are made, there is another high-ceilinged, especially ventilated flameproof area for conducting experiments in the combustion of gases and processing of metals. There are, also, a number of conventional service laboratories, such as an X-ray room, chemical laboratory, mechanical testing laboratory and metallographic laboratory, plus specially equipped laboratories, including a high-pressure oxygen laboratory and a compressed gas cylinder testing laboratory.

The entrance lobby is located in one of the two wings and is adjacent to the meeting point of the main portion of the building in those wings. Next to the lobby is a large drafting and design room with windows on three sides in order to take full advantage of the natural light. This ceiling, as well as all ceilings in the offices and corridors, contains fluorescent lighting fixtures recessed into a hung acoustical ceiling.

Approximately 50 two- and three-man offices are provided for those engaged in engineering and research, thus insuring the privacy necessary for creative thinking. The exact number of rooms is variable since the building is of the modular unit type utilizing portable steel partitions so that the number and dimensions of these rooms can be altered at will.

A modern cafeteria, owned and operated by the company on a nonprofit basis, occupies the only part of the building over two stories in height.

"CUTTRODE," SPECIAL ARC METAL CUTTING TOOL

Low-cost surface and underwater metal cutting by means of a spectacular new electric arc-vapor metal cutting tool known as the "CutTrode" was demonstrated for the first time November 21st in the research laboratories of Eutectic Welding Alloys Corp.

According to announcement by R. D. Wasserman, president of Eutectic, "CutTrode" carries a special exothermic coating for focusing and intensifying the energy of the electric arc, so that steel plates or sections are sliced through with scalpel-like precision, without the necessity for elaborate external equipment such as oxygen and gas tanks.

CATALOG LISTS X-RAY MATERIALS

A new, sixteen-page, illustrated catalog, published by the Eastman Kodak Co., lists materials and accessories for industrial radiography.

Included in the catalog listings are films, exposure holders, intensifying screens, chemical preparations for processing, darkroom accessories and viewers. A chart indicates the relative speed and contrast of different types of X-ray films for computing exposure.

The catalog is available without charge from the X-ray Division, Eastman Kodak Co., Rochester 4, N. Y.

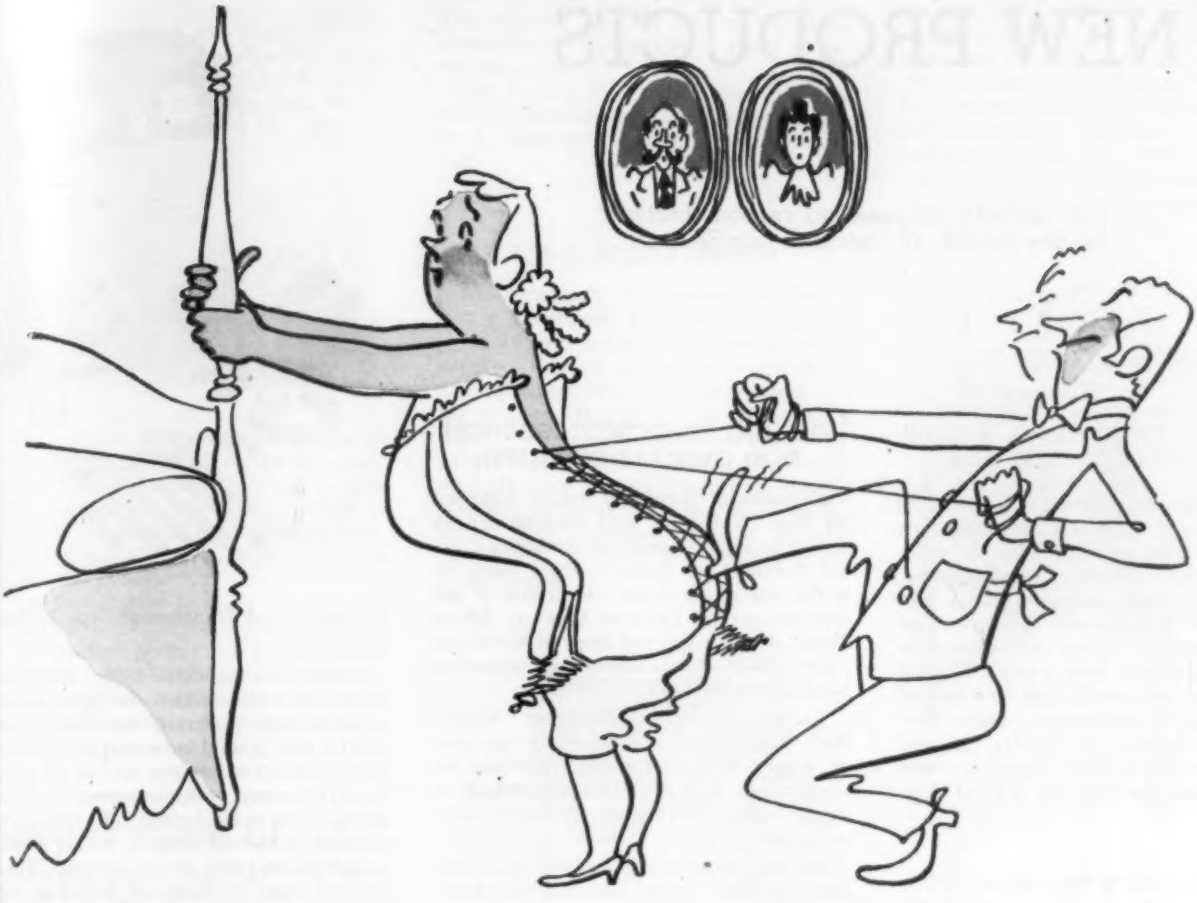
LINDE TO EXPAND FACILITIES AT LITTLE ROCK

Construction will start soon on an oxygen filling station and acetylene producing plant at Little Rock, Arkansas, The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation, announced recently. The plans also include a warehouse for the distribution of Union Carbide.

Employment Service Bulletin

SERVICE AVAILABLE

A-554. Welding Engineer. Worked for Bethlehem Steel Co., Maryland Drydock Co., Navy Department, Bureau of Ships and Terminal Island. Practically all of this time was spent in the Fusion Welding field, using full automatic, semi-automatic and hand welding, setting up proper welding procedures and sequences. Attended Johns Hopkins University. 42 years of age; married. References furnished on request.



The Case of the Controlled Contours

Contour control is most important . . . especially to achieve good results in welding operations!

McKay Electrodes have the particular properties needed for proper regulation of bead contour, as well as weld metallurgy and arc action.

With McKay Electrodes, the operator lays down beads which are the exact size and shape required by the job. The weld metal is metallurgically sound, free from slag inclusion and has the correct mechanical properties.

Thus McKay Electrodes assist in producing stronger structures with less weld metal and lower finishing costs. *See for yourself. Test McKay Shielded-Arc Electrodes on your next job.*

THE McKAY COMPANY
406 McKAY BUILDING
Pittsburgh, Pa.
Sales Offices: York, Pa.

Get the full story of

McKAY ELECTRODES

Write or phone for detailed information on the complete line of McKay Shielded-Arc Electrodes. Our Technical Staff can recommend the electrodes best suited to your needs.

McKAY STAINLESS STEEL • MILD STEEL • ALLOY STEEL • WELDING ELECTRODES

Researched, Developed and Manufactured to fill Industry's Requirements for Dependable Electrodes

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

ELECTRODE FOR MAKING MACHINABLE WELDS ON CAST IRON

A new electrode, "Hobart Softcast A," is a copper-nickel alloy electrode having a mineral flux coating for metallic arc welding. The weld deposits are nonferrous, light gray in color, malleable, easily machinable and have a tensile strength equal to good cast iron. They are adapted to the welding of cast iron where the weld area must be machined, drilled or tapped anywhere in the weld zone. These electrodes are available in $^{3}/_{32}$, $^{1}/_{8}$, $^{5}/_{32}$ and $^{3}/_{16}$ in. diameters in 18-in. lengths, center brushed. May be used on a.-c. or d.-c. current.

FLEXARC LoH ELECTRODE

A new hydrogen-free, mineral-type, extrusion-coated electrode that eliminates "underbead cracking" is available from Westinghouse Electric Corp. Ranging in diameters from $^{1}/_{4}$ to $^{1}/_{8}$ in., these electrodes are recommended for use with direct-current reverse polarity and also for alternating current.

It is known that hydrogen occurring in welds can be very harmful under certain circumstances as it is taken into solution in molten steel and if substantial amounts of hydrogen, or gases containing hydrogen, are produced, substantial amounts can be absorbed in the weld. If the conditions are such that this hydrogen cannot escape before the metal solidifies, it will later be released when the metal cools and cause underbead cracks.

Typical of the applications of this electrode are: welding high-carbon steels, welding high-carbon to low-alloy steel; welding low-alloy steels; welding high-sulphur bearing steels not heretofore weldable; welding mild steel structures that are to be vitreous enameled without previous heat treating and for welding steel parts of unknown analysis.

These electrodes require lower arc voltages than the E-6010 or E-6020 mild steel electrodes and use slightly high current values. Their application is typified by an extremely quiet arc action and the absence of the usual spatter.

Further information about the Flexarc LoH electrode may be obtained from the Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

NEW GAS "EUTECROD" PRODUCES Rc 67 OVERLAYS ON COPPER

Deposits of beryllium copper followed by heat treating or cold working are no longer required to produce maximum overlay hardness on copper—where hardness is the sole requirement—according to announcement by Eutectic Welding Alloys Corp., of a new gas welding rod known as "EutecRod" 188, having a maximum hardness up to 67 Rc.

According to the manufacturer, "EutecRod" 188 is the only alloy which can produce overlays of such extreme hardness on copper, which it does as deposited, in a single pass, requiring no additional heat treatment.

Special applications include bearings, gears, marker teeth, agricultural equipment, as well as centrifugal pumps, chemical processing components, globe or gate valves, oil-jet nozzles and other machinery where corrosion-resistance is important.

The new alloy has a bonding temperature of 1800° F. and remelts at 1950° F. In addition to producing extreme overlay hardness on copper, the new alloy applies equally well to steel and ferrous metals generally, again without dilution with the base metal during the welding process. It is characterized by high resistance to corrosion, including nitric, acetic, phosphoric, tartaric and citric acids.

For additional information, write the manufacturer at 40 Worth St., New York 13, N. Y.

LIMITED INPUT TYPE WELDERS

Several new, improved, general-purpose, Limited Input transformer-type welders have been added to the "Job-Tested" Trindl Welder Line for use on single phase, rural and other power lines of limited capacity.

Designed to conform with both R.E.A. and N.E.M.A. specification requirements, these new improved welders are fully approved by Underwriters, Laboratories and are available both with and without power factor correction in output ratings of 130 and 180 amp. Prices start at $155.50 complete, ready to operate with headshield, electrode holder, welding, ground and power cables, wall receptacle, generous supply of assorted welding rods and simplified welding and operating instructions which are actually a short course in welding.

Limited Input Transformer Type Welders

These new models—130B, 130C and 180B and 180C—which are highly recommended and preferred for farm, automotive and general industrial maintenance and production welding because of sensational economy, performance and dependability, bring to the farmer, automotive and general industrial shop a welder ideally suited for all types of repair work. These welders have 36 foolproof secondary output current heat stages ranging from 20 amp. to their rated maximum secondary outputs of 130 and 180 amp., respectively.

Class B spun glass type insulation is used throughout. Natural ventilation, no moving parts and sloping Vernier-type control panel, are only a few of the many outstanding features of this equipment.

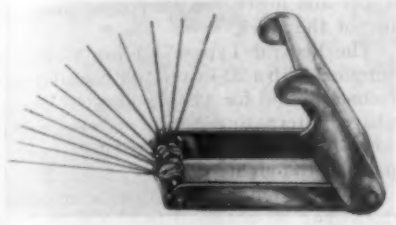
Catalog sheets describing these new welders are now available. For complete information write Sales Department, Trindl Products, Ltd. 17 East 23rd St., Chicago 16, Ill.

THE NEW HOBART ARC WELDERS

The Hobart Brothers Co., Troy, Ohio, now has available a new 36-page, 3-color catalog containing illustrations, descriptions, dimensions and specifications on its complete line of "Simplified" arc welders which includes electric motor driven d.-c. welders in 5 sizes from 150 to 600 amp.; gasoline engine driven welders in 4 sizes from 200 to 600 amp.; a.-c. transformer type welders in 3 sizes from 200 to 500 amp.; welding generators only in 4 sizes from 150 to 400 amp.; gasoline-engine driven welders with auxiliary a.-c. or d.-c. power generators; and other models in all sizes for special arc welding applications. Various features comprising the machines are individually illustrated and described, and helpful information is given for various welding problems. Also listed is the complete line of Hobart arc-welding electrodes and accessories. Anyone desiring a free copy of this catalog is requested to write direct to the company.

TIP CLEANER

A newly designed set of cleaners for acetylene welding tips, contained in an aluminum case, is announced by the manufacturers, Thermacote Mfg. Co., 420 S. San Pedro St., Los Angeles 13, Calif.



Standard set of 12 cleaners will clean 27 drill sizes from #74 to #49, while the special set cleans 19 drill sizes from #47 to #30. The cleaners are specially designed to clean the tips without damaging the ports, thus insuring a long, straight flame for clean, slagless cuts.

The metal case protects the cleaners from being bent, or otherwise damaged, in the welder's pocket. A list of cleaner sizes to be used with the various drill numbers is engraved on the back of each case so that the correct size can be immediately selected.

RESISTANCE WELDING ELECTRODES

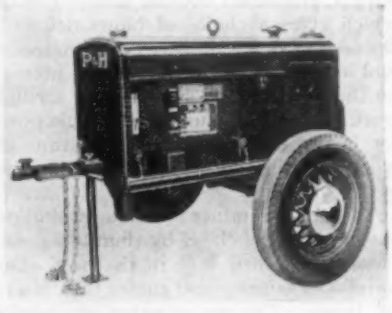
Announcement is made by P. R. Mallory & Co., Inc., of a specially designed water-cooled light-duty holder for resistance welding electrodes.

The new holder was designed for those hard to reach spot welds. The light duty holder incorporates a button type, replaceable electrode held in place by an easily removed Allen Head screw. Water cooling is efficiently brought as near the electrode as possible to insure maximum electrode life under the most severe usage. Almost 4 in. of offset adjustment is available by merely setting the minimum amount of offset desired and setting two Allen Head bolts in the "T" connection head. Shank length is 3 in. with diameters of 3/4, 7/8, 1 and 1 1/4 in. The complete holder with the exception of Allen Head bolts and water connections is made from superior Mallory 3 metal bar stock possessing the highest electrical and physical properties.

For further information on resistance welding electrodes and holders write to the P. R. Mallory Co., Inc., Indianapolis 6, Ind.

P&H PORTABLE WELDER

An important new feature of the recently announced P&H Model WN-200 portable arc welder is its extra power supply. Offered as optional equipment at small extra cost, the unit provides 1 1/2 kw. of alternating current at 115 v., single phase. This enables operators to hook up electric lights for floodlighting while welding. It also permits the use of electric powered tools, such as grinders, chippers, drills. Any universal a.-c.–d.-c. portable tool may be operated from this additional power source.



The welder having this feature was announced recently by the Harnischfeger Corp., Milwaukee, manufacturer of P&H products. The P&H WN-200 Welder, available as a trailer or stationary model, is an N.E.M.A. rated machine of 200 amp., but has a welding service range of from 30 to 260 amp. The welder has just one control for any desired welding heat, from minimum to maximum capacity.

For further information on this d.-c. welder with the additional a.-c. power supply, write the manufacturer, Harnischfeger Corp., Welding Division, 4400 W. National Ave., Milwaukee 14, Wis.

KERN A.-C. WELDERS

A new line of a.-c. welders has been developed by the John A. Kern Co., 224 (64) N. Loomis St., Chicago 7, Ill. The line includes three industrial models—200, 300 and 400 amp., and two models for farm and general shop use—130 and 180 amp. All models are N.E.M.A. rated, with the two farm models meeting the requirements of rural utilities and R.E.A.

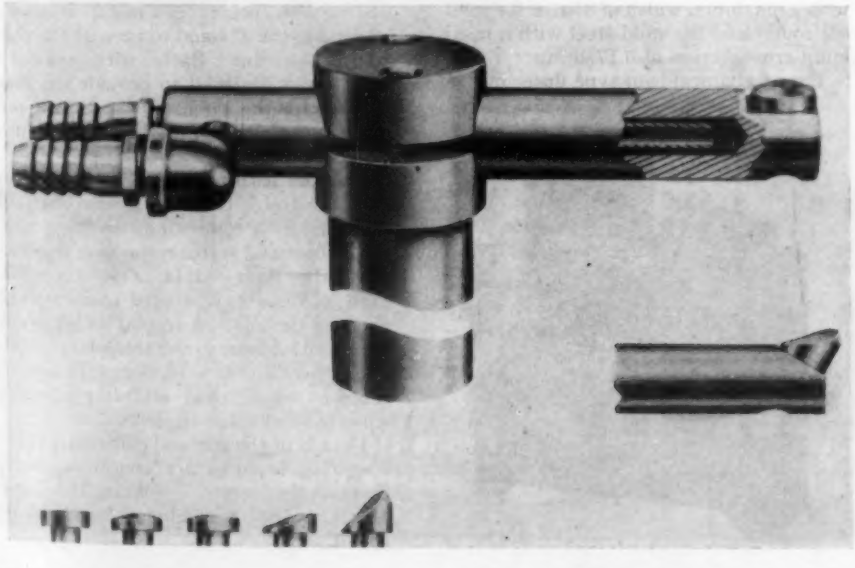
Notable features of all models, claimed by the manufacturer, are:

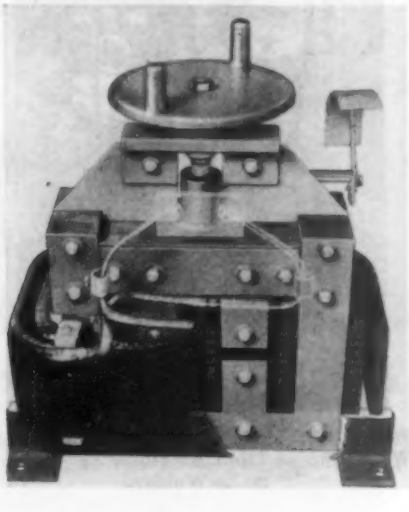
1. Patented electrical and magnetic circuits which result in an instant starting, smooth and stable arc, at all amperage settings. The design also produces high power factor, reduces "no-load" losses and results in high efficiency.

2. Compactness to an unusual degree is due to the fact that the movable core on all models travels less than 1 in. to cover the entire range of stepless amperage control. The arrangement of dual primary and secondary coils and the elimination of arc boosters, reactor coils and fans also contributes to the compact design.

3. The absence of rotary parts results in quiet operation and virtually eliminates the need for lubrication and maintenance.

4. Efficient cooling is brought about by providing ample air passages around





coils and cores. The air intake at the bottom of the housing is more than a foot above the floor, thereby eliminating the chances of dust and dirt restricting the air flow.

5. Carriages are welded steel tubing and are equipped with large diameter, wide rim, cast aluminum wheels as standard.

Further information is available by requesting circular No. 101 from the manufacturer.

WELDOMATIC WELDER

Everything needed for automatic welding—welding head, control equipment, welding transformer and work-positioning equipment—is available from Westinghouse Electric Corp. in a single package. This is the first complete package of automatic welding equipment engineered, built and sold by a single manufacturer.

The standard weldomatic head, suitable for welding with alternating or direct current, operates with a capacity of 1200 amp. a. c. Special nozzles are available for 2000 amp. a. c. Capacity for d.-c. welding is 800 amp. The head is so designed that it can be rotated 360° in the vertical or horizontal plane. As a result, it can be mounted in any position for welding. Nozzles and knurled-drive wire feed rolls are supplied to accommodate 1/8, 3/32, 3/16 and 1/4 in. wire diameter. Wire feed is automatic. The speed of the driving motor is controlled by the burn-off rate of the welding wire through a bridge hook-up consisting of arc voltage, control generator field and a potentiometer.

The motor-generator set is driven by a 2-hp., 220/440 v., 3-phase, 60-cycle a.-c. motor. A 2-pole constant-potential generator supplies the control current and a 2-pole variable-voltage generator supplies current to the driving motor in the head. Control relays and contactors required in the operating circuit are mounted in the control panel. Control equipment for starting and stopping the welding arc and traverse mechanism, as well as adjustment for arc length, is mounted on the operator's panel.

The work-positioning equipment is supplied as needed for the job from semi-standard designs of travel carriages, mounting pedestal, rotator, positioner and turning rolls.

Further information about the Weldomatic welder may be obtained from the Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

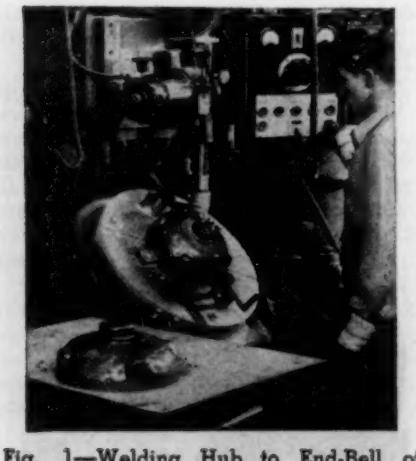
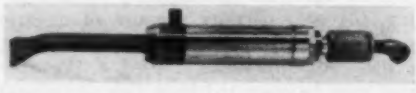


Fig. 1—Welding Hub to End-Bell of Westinghouse Life-Line Motor on Weldomatic Welder

SCALING HAMMER

The Rotor Tool Co., Cleveland, Ohio, announces a new S-1 Scaling Hammer for the following applications: Weld flux scaling, weld spatter removal, paint scaling, rust removal, removing fins from castings, peening, chipping, star drilling, etc.



This new tool is fast, rugged and light, with a graduated control in the throttle which gives a choice of blows delivered, thus covering a wide variety of production and maintenance work. Light pressure on the valve meters sufficient air for light work, heavier pressure gives ample power for heavy cuts. Exhaust air cleans the work of chips and scale and thus gives better visibility.

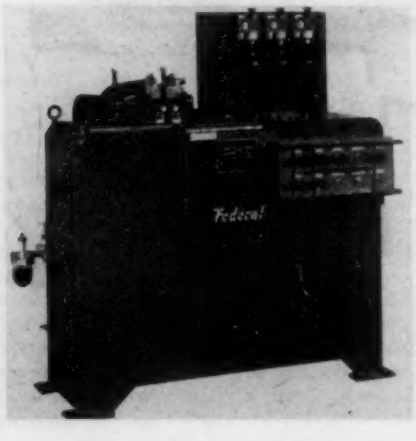
The chisel retainer is unique and allows easy removal of chisel by thumb pressure. Square broached hole in the nose eliminates nose bushing and guides the chisel at all times. The wafer valve of stainless steel is simple and compact.

Chisels are furnished in blank form, flat form, spoon form and a full line of star drills is available in sizes 3/16 to 3/4 in. Weight, 3 lb.; length without chisel, 10 1/4 in.

FLASH WELDER

The Federal Machine and Welder Co., announces development of a new flash welder conforming to RWWA specifications. The machine, designated as the Federal Type F-1 Flash Welder, is designed for welding flat mild steel stock with a maximum width of 3 in. or for welding round and flat mild steel with a maximum cross section of 0.17 sq. in.

The mechanical cam-type upset mechanism is located below the weld line in order to prevent obstruction above the weld line. Upset pressure of 2250 lb. is applied to the work when a platen opening of 1/4 to 2 in. is used. Platen size is 12 x 12 in. The machine is equipped with air-operated vertical clamps and adjustable upper and lower dies for correct positioning of the work.

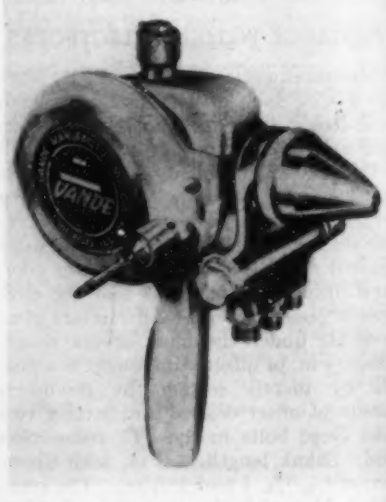


The Federal Type F-1 Flash Welder is supplied with a 20-kva. water-cooled transformer wound for 440-v., 60-cycle, single-phase, alternating-current power supply with 16 steps of heat regulation, series-parallel and eight steps.

Further details or complete specifications may be obtained from The Federal Machine and Welder Co., Plant 2, Warren, Ohio.

METALLIZING GUN FOR SPRAYING METALS

The Vande Mfg. Co. of Chicago has introduced a new metallizing gun embodying several exclusive design features. The manufacturer reports faster and more thorough application of metals such as steel, aluminum, zinc, lead, bronze, copper, nickel and others.



The gun completely eliminates backfire. Its nozzle incorporates a new development of mixing the gas and oxygen at the point of combustion. Each wire nozzle is specifically designed to provide the exact volume for the gas used: acetylene, propane or other gas. No air cap adjustments are needed.

Another feature is the Finger-Tip Turbine Control. Positive turbine control is achieved by a compound turbine containing a rotor and stator responsive to opposing propulsion fluids. One propulsion fluid jet remains in a fixed position in the primary turbine. A second jet is directed by a control lever in the secondary turbine and either reduces or increases the primary turbine speed, thus affording complete wire feed control at all times.

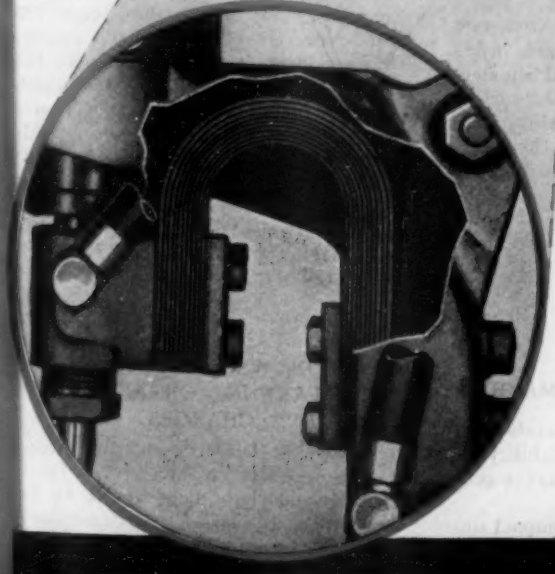
Details of the gun and explanation of its operating features are contained in the Company's literature. Write the Vande Mfg. Co., 1837 S. Michigan Ave., Chicago 16, Ill.

•MARTIN•

AIR or HYDRAULIC SPOT WELDING GUNS

A High-Speed Cost-Cutting Production Tool Designed for Flexibility, Lightness and Durability, and Featuring . . . . . the

Non-Kick ROLLING SHUNT



Martin Spot Welding Guns cut costs and speed up work progress on jobs too bulky or otherwise unsuitable for special welding fixtures and welding machines. They're adaptable, through custom-built yokes and adaptors, to the full range of job shop work. Typical of Martin superiority is the exclusive Rolling Shunt (see cutaway section at left). This production-tested design eliminates cable "kick," reduces operator fatigue, gets more work done because it works *with* the welder, not against him. Write for literature and the name of your nearest Martin representative.

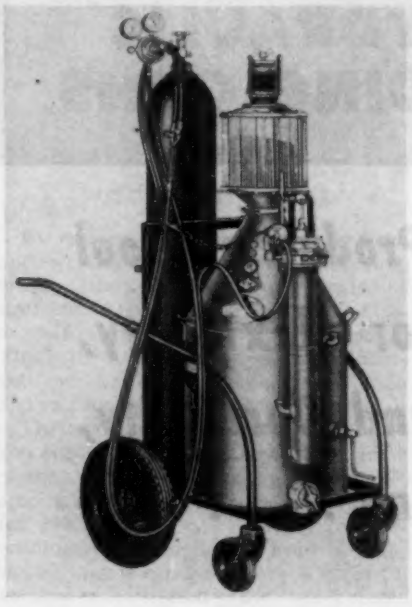
MARTIN ELECTRIC COMPANY

3040 E. OUTER DRIVE • DETROIT 12, MICHIGAN

Manufacturers of Portable Spot Welding Guns • Transformers • Special Automatic Welding Machines and Standard Pedestal Type Welders

ACETYLENE GENERATORS

Completely redesigned and improved, these new 14ND Carbide Acetylene Generators feature lighter weight, greater portability and maximum safety.



The visible supply hopper has been reduced in weight by the use of steel stampings. This means lighter weight, easier, faster recharging. By reducing weight and using the new pneumatic rubber-tired trucks, announced recently, the generator has much greater portability.

The Model "PS," like other Sight Feed Generators, bear the UL and FM stamp of approval and have been made even safer by the addition of the Sight Feed Safety Check. The safety check will stop all flashbacks which come from improper operation of the torch.

The Model "PS" generators are available in four sizes. The 6-PS, 30 cu. ft. per charge; the 12-PS, 60 cu. ft. per charge; the 25-PS, 125 cu. ft. per charge; the 50-PS, 250 cu. ft. per charge.

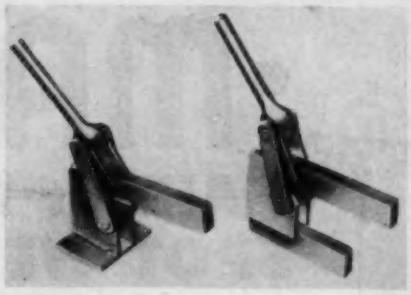
Complete literature covering this new line of portable acetylene generators is now available through the Sight Feed Generator Co., Richmond, Ind.

ALL WELDED HEAVY DUTY CLAMP

The General Welding Co., 7404 Euclid Ave., Cleveland, Ohio, announces a new line of all-welded toggle clamps. These clamps are designed to withstand the most severe service such as heavy fabricating. They are of extra rugged construction with all pivot pins welded to the frame and linkage making a rigid unit that will not twist or come apart. The design of the linkage provides double the clamping pressure of ordinary clamps.

The clamp on the left is the Model A-2. This type is very useful on drill jigs, milling fixtures, etc.

On the right is the Model B-2 which is an extremely versatile clamp. This type can be used with either bar acting as the clamp bar. This feature enables it to be



used where other types would obstruct the work such as intricate welding or assembly operations.

A two-color descriptive bulletin is available upon request.

FLEXARC CARBON ARC TORCH

The Westinghouse Flexarc carbon arc torch for brazing, soldering and supplying heat for light forging, preheating before welding and tempering operations is available from Westinghouse Electric Corp.

Each torch comes complete with two 10-ft. extra flexible welding cable leads attached; one pair 1/4 x 6-in. carbon electrodes; and one pair 3/8 x 6-in. carbon electrodes. Leads are equipped with bayonet attachment plugs to fit the Westinghouse WT Midget Marvel and Limited Input welders.

Further information on the Flexarc Carbon Arc Torch may be secured from Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

HEAVY DUTY ARC-WELDING MACHINE

The Wilson Welder and Metals Co., Inc., has announced the availability of the new Wilson "Hornet" 36A motor generator arc-welding machine.

The new "Hornet" 36A of compact design and available in 200-, 300- and 400-amp. models is a heavy duty machine with simple control of current that is easy to adjust and preset accurately. It is smaller in size and weighs one-third less than the previous "Hornet" models—factors which save valuable floor space and provide easier movement. This machine is designed for either 220 or 440 v. with no change in relays or additional wires being required for voltage re-connection.

The heavy duty "Hornet" 36A is designed to furnish a smooth steady current for every conceivable industrial welding job under the most adverse conditions, because of its weather-resistant, totally enclosed drip-proof construction and special moistureproof insulation.

Further information on the new Wilson "Hornet" 36A arc welder can be obtained by writing directly to Wilson Welder and Metals Co., Inc., Dept. 1609P, 60 E. 42nd St., New York 17, N. Y., or Air Reduction Sales Co. and its authorized dealers or Graybar Electric Co., Inc.

NEW ELECTRODE FOR DOWNHAND WELDING OF HIGH TENSILE LOW ALLOY STEELS

A new electrode, "Hobart No. 111HT," is a shielded arc-welding electrode designed for welding low-alloy high-tensile steels in the down-hand positions such as deep groove, positioned and horizontal fillet welds. The forceful spray type arc makes it unusually easy to handle and the spatter loss is very low, which results in a high rate of metal deposit. Slag is easily removed and cleaning time is reduced to a minimum. Physical properties are: tensile strength, 70,000 to 80,000 lb. psi.; yield point, 65,000 to 70,000 lb. psi.; elongation, 25 to 30%. These electrodes are available in 3/16 in. and 1/4 in. diameters only, 18 in. lengths. Can use either d.-c. or a.-c. current.

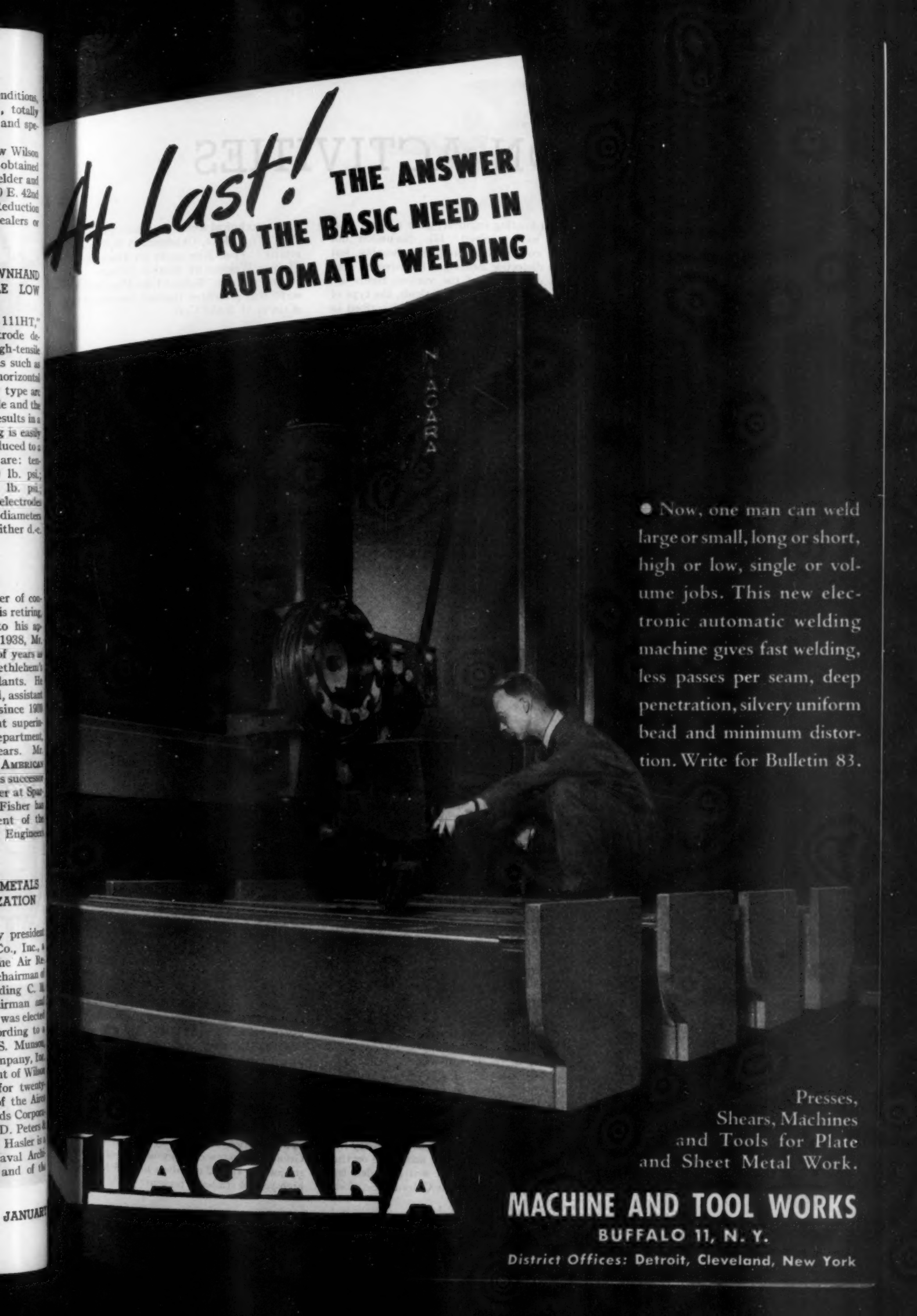
GERHARDT RETIRES

R. B. Gerhardt, chief engineer of construction, Bethlehem Steel Co., is retiring, effective January 1st. Prior to his appointment to that position in 1938, Mr. Gerhardt served for a number of years as assistant general manager at Bethlehem's Sparrows Point and Steelton plants. He will be succeeded by L. J. Gould, assistant chief engineer of construction since 1939 and prior to that time assistant superintendent of the mechanical department, Sparrows Point, for twelve years. Mr. Gould is a member of the American Welding Society. Mr. Gould's successor will be A. J. Fisher, fuel engineer at Sparrows Point since 1929. Mr. Fisher has been elected National President of the Association of Iron and Steel Engineers for 1948.

WILSON WELDER AND METALS COMPANY, INC. ORGANIZATION CHANGES

Thomas B. Hasler, formerly president of Wilson Welder & Metals Co., Inc., a wholly owned subsidiary of the Air Reduction Co., Inc., was elected chairman of the board of directors succeeding C. F. Adams who resigned as chairman and director; and F. B. Adams, Jr. was elected president and a director according to a recent announcement by C. S. Munson, president of Air Reduction Company, Inc.

Mr. Hasler has been president of Wilson Welder & Metals Co., Inc. for twenty-nine years and is a director of the Airco Export Corporation and Arcrods Corporation, and vice-president of G. D. Peters & Co. of Canada Limited. Mr. Hasler is a member of the Society of Naval Architects and Marine Engineers and of the Propellor Club.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SECTION ACTIVITIES

ATLANTA

At 8:00 P.M., Tuesday Night, November 18th, a meeting was held in the Mechanical Engineering Building at Georgia School of Technology, which was addressed by Ira T. Hook of The American Brass Co., Ansonia, Conn. Mr. Hook gave an illustrative lecture on Copper Mining and the Welding of Copper, Brass and Bronze. He showed a very interesting colored film on Copper Mining in Chile.

BOSTON

Regular dinner meeting of the Boston Section was held on November 3rd at the Engineers' Club. The dinner speaker was Dom Meo who told of his experiences in South America. Technical speaker was Vincent T. Malcolm, who spoke on Welding Techniques at Chapman Valve and also showed a movie on Welding of Valves. Both talks were very well received. Refreshments of cider and doughnuts were served after the meeting.

The December dinner meeting was held on the 1st at the Engineers' Club. R. D. Thomas, Director, and J. G. Magrath, National Secretary of the A.W.S., spoke prior to the technical session. G. O. Hoglund of the Aluminum Co. of America, presented a technical address on Welding and Brazing the Aluminum Alloys. A film on How to Weld Aluminum was also shown. Refreshments were served after the meeting.

BRIDGEPORT

A steak dinner meeting was held on November 20th at The Candlelight Restaurant. Speaker of the evening was John F. Willis a member of the Bridge Division of the Connecticut State Highway Dept. Mr. Willis presented an illustrated talk on Welding's Place in Bridge Construction.

CHATTANOOGA

The following officers have been elected to serve the Chattanooga Section for the fiscal year:

Chairman, J. F. McElwee, Jr., General Electric Co.; *Vice-Chairman*, J. W. Kelker Jr., Combustion Eng. Co.; *Secry.-Treas.*, Ralph Baker, Welding Gas Products Co.; *Program Chairman*, P. O. Leach, Combustion Engineering Co.

CHICAGO

The November meeting of the Chicago Section was held on the 21st. Guest speaker was Harold Bunte, Commonwealth Edison Company, who spoke on "Brazing and Other Applications of High Frequency Heating." Mr. Bunte, an electrical heating engineer, gave a paper that was well received. His discussion not only covered high frequency heating, but also dielectric heating. He covered general definitions of the various terms applied to these heating methods, the type of equipment that is used, and described in some detail the differences between a motor generator, a spark gap and electronic tube equipment. Mr. Bunte's talk, which was illustrated with slides, also covered the various applications of high frequency heating in brazing and soldering operations.

CINCINNATI

Mr. Carl B. McLaughlin of Tube Turns Inc., presented an interesting talk entitled "Piping Developments, A Challenge to the Welding Profession," at the November 25th meeting. He explained their use and application. Slides on "Carbide Precipitation in Stainless Steels" were also shown. Following the meeting a "Dutch Lunch" was held for all members and their guests.

CLEVELAND

James F. Lincoln, President of The Lincoln Electric Co., was the technical speaker at the December 10th meeting. His subject was "Arc Welding Is Being Handicapped."

Mr. Lincoln, who is a member of the A.W.S., is also a member of the A.I.E.E., the A.S.M.E., Cleveland Engineering Society and Engineers' Club of New York. He gave a very interesting talk pointing out the restrictions that must be removed in order for arc welding to achieve its full development and rightful place in American industry. Mr. Lincoln documented his discussion with many specific examples.

"Gem Stone Lore" was the subject of the coffee talk given by William F. Poese, a teacher in the Cleveland Public Schools, in which he showed many samples of the beautiful work which he started as a hobby, and later developed into a business. This was one of the regular "coffee talks" which are part of the Cleveland Section's program of introducing subjects of interest, but completely unrelated to arc welding.

COLORADO

The November 11th meeting was held in the Silver Wing Inn, Denver. This was one of the largest meetings this Section has had in almost a year and there was a very enthusiastic audience. There were 18 members present from the Hartford Steam Boiler Inspection and Insurance Co. Mr. Schmuck, Membership Chairman, gave a talk on the necessity for new members. A report was made on the Chicago meeting which was attended by four of the officers of the Colorado Section.

The technical session was addressed by Prof. W. A. Rice, Oklahoma A & M University. Prof. Rice spoke on Training of Electric Welders by Motion Pictures. A motion picture "Welded Line Pipe Smithway" was presented through the courtesy of the A. O. Smith Corp.

COLUMBUS

Dinner meeting was held on Friday, November 14th, at the Hotel Fort Hayes. "Resistance Welding—Design Application," was the subject presented by R. T. Gillette of the General Electric Schenectady Works Laboratory. Mr. Gillette first joined the General Electric Co. in 1901 as a member of the Research Laboratory. For the last two decades he has been following resistance welding research, having transferred to the G-E Works Laboratory development section in January 1926. With his broad experience in the Resistance Welding field, he was in a position to present a paper of interest to all in the Resistance Welding field.

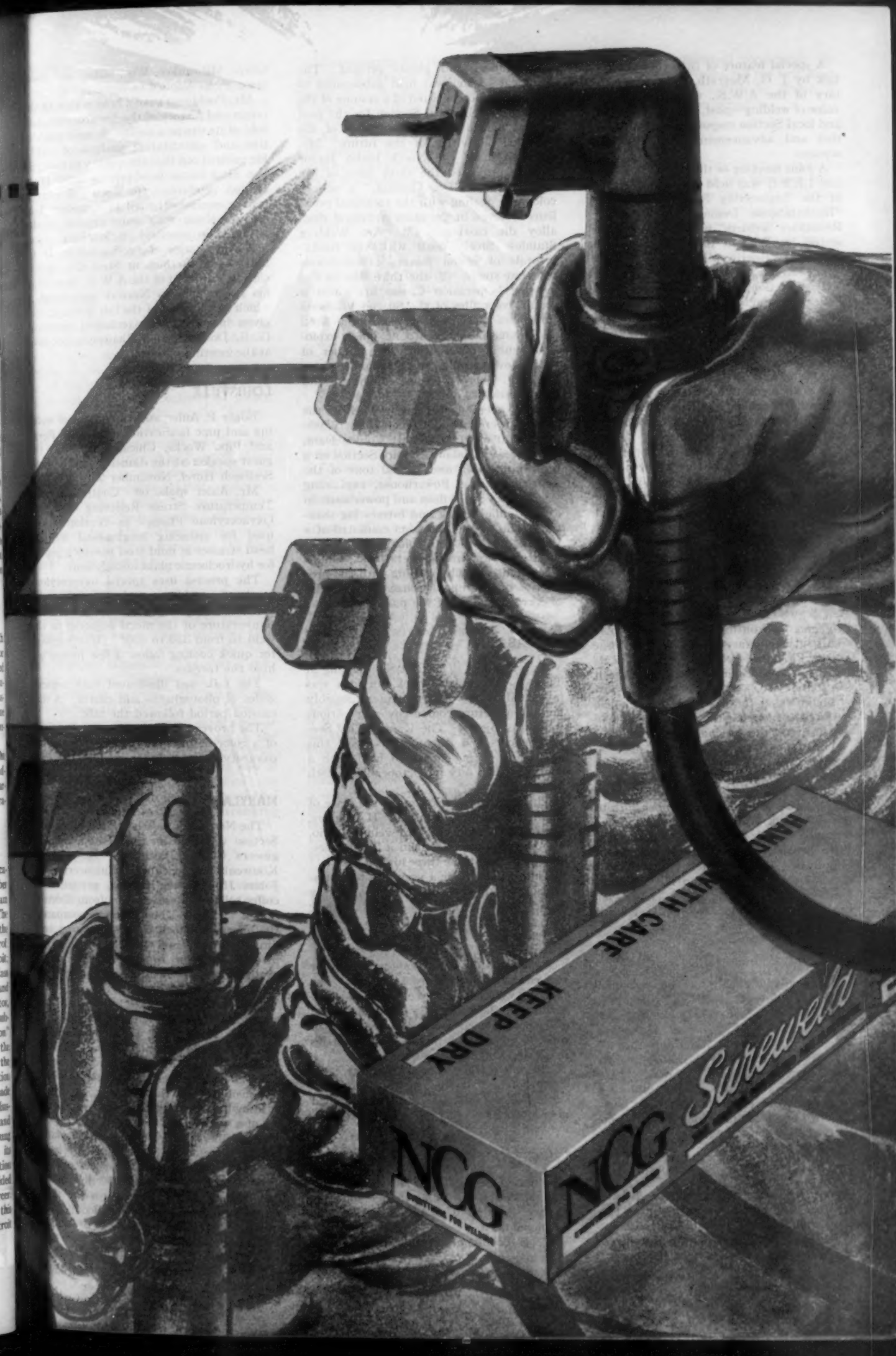
DAYTON

October meeting was held on the 29th at The Engineers' Club. The speaker for the evening was E. H. Turnock, associated with Westinghouse Electric Corp., nationally known in the field of electrode processing and development, which is of prime interest and importance to everyone connected with the welding industry.

The November meeting, held on the 19th at The Engineers' Club, was addressed by A. M. Setapen of Handy & Harman. Mr. Setapen discussed low-temperature silver alloy brazing.

DETROIT

Representatives of progressive educational institutions spoke at the November 14th meeting held in the Rackham Engineering Foundation Building. The speakers included Prof. L. E. Wagner of the University of Michigan, Ann Arbor; Prof. A. C. Good of Wayne University, Detroit; Carl Turnquist, Welding Instructor at Cass Technical High School, Detroit, and Andrew Althouse, Vocational Director, Board of Education, Detroit. The subject "The Future of Welding Education" is believed by the Section to be one of the primary obligations and reasons for the existence of the A.W.S. This Section believes that every effort should be made by all local Sections to interest the industries and school systems to promote and demand welding education for its young men. Welding should be raised to its proper professional status and recognition and young men shown the many-sided opportunities in welding as a career. Great interest was expressed toward this subject by the 82 members and 26 Detroit high school students present.


KEEP DRY
NCG
Surewelds

A special feature of the program was a talk by J. G. Magrath, Executive Secretary of the A.W.S., who spoke on the value of welding—past, present and future, and local Section responsibility for promotion and advancement of the welding sciences.

A joint meeting of the A.I.E.E., A.W.S. and I.E.E.S. was held on November 13th at the Engineering Society of Detroit. "Instantaneous Demand on Groups of Resistance Welders" was the subject presented by William G. Bostwick of the Precision Welder & Machine Co.

The Saginaw Valley Division of the Detroit Section were guests of the Wickes Boiler Co., Saginaw, Mich., for the Division's third regular meeting of the year held November 13th.

The Wickes Boiler Co. are manufacturers primarily of heavy boilers and use welding practically 100% in their fabrications. In order to show their guests the various operations in actual production, the company brought in daytime operators on an overtime basis. This, the Section feels represents outstanding cooperation with the SOCIETY and the Wickes Boiler Co. is to be highly commended.

The program, including the question-and-answer period after the plant inspection, was under the supervision and direction of Robert Lyman, Plant Superintendent of the Wickes Boiler Co. "Bob" did an excellent job and is to be congratulated.

The meeting was attended by Joe Magrath, Executive Secretary of the A.W.S., who gave a short discussion of the problems confronting the organization.

Also in attendance as guests were George Sieger, First Vice-President of the A.W.S., and A. Last, Chairman of the Detroit Section.

There was a total of 87 in attendance, despite the fact that the meeting was held on the eve of the deer hunting season.

HARTFORD

Dinner meeting of the Hartford Section was held on Thursday, November 20th in the Whitlock Manufacturing Co. Cafeteria, Elmwood, Conn. Patrick S. Doyen, Field Engineer, Welding Equipment and Supply Co., Detroit, Mich., presented an illustrated talk on Tool and Die Welding. Two sound slide films titled "Let's Get the Lowdown" and "Let's Do It Right" were shown.

INDIANA

The regular monthly meeting was held on Friday, November 21st, at Buckley's, Cumberland, Ind., G. O. Hoglund of the Aluminum Co. of America spoke on "Welding and Brazing Aluminum Alloys." Mr. Hoglund also showed a movie on gas and arc welding and one on brazing. He also showed a number of slides showing applications of welded aluminum construction with considerable emphasis on Argon-shielded tungsten arc welding.

INLAND EMPIRE

The October meeting of the Inland Empire Section was held on the 9th at the Log Cabin Inn in Coeur d'Alene, Idaho. A fine chicken dinner was much enjoyed by members and guests present. The technical session was held subsequent to the dinner and consisted of a résumé of the activities of the local Section for the past several months and a statement of the intended activities of the future. Mr. Christenson of the North Idaho Junior College projected the three films of the evening: (1) "Die Casting," a sound, color film dealing with the technical problems involved in the manufacture of zinc-alloy die castings; (2) "Arc Welding Stainless Steel" dealt with the fundamentals of fusion joining of corrosion-resistant steels; (3) the third film of the evening "Operation Crossroads," was a sound, color film of the Special Weapons Project of the U. S. Navy at Bikini Atoll and exemplified the atomic bomb explosions under observation. A number of local townspeople were among those present. There were 47 members and guests present.

The November meeting was held in the West Powerhouse at Coulee Dam, Wash. S. E. Hutton, Engineer at Coulee Dam, conducted the Inland Empire Section on a most interesting and special tour of the Dam and West Powerhouse, explaining the features of the dam and powerhouse in a most enlightening and interesting manner. The technical session consisted of a showing of the sound, color film, "Golden Horizons," an Ampco Metal, Inc., film, a general interest film dealing with the production of aluminum bronze and a résumé of correspondence of the past month.

KANSAS CITY

As a result of a District Six meeting in Tulsa a few months back, an idea was presented as to various chapters possibly holding a lecture course covering various welding subjects. The Kansas City Section officers and directors discussed this and made arrangements to hold such a course in their city on October 27th, 28th and 29th.

This course was also to take the place of their monthly meeting. R. H. Davies, Consulting Engineer of Cleveland, Ohio, was the speaker. He held a $2^1/_2$-hr. session on each of these three nights.

The speaker made a very nice presentation of his subjects, which covered a very broad field. Principal subjects were: (1) type of equipment to be used for various electric welding processes; (2) strains and stresses; (3) joint design.

Approximately 375 tickets were sold for this course at a price of $3.00 each. The meeting was held in one of the class auditoriums at the University of Kansas City, and there was an average attendance of over 300 men from all types of industries in Kansas City and trade territory.

The officers and directors of the local chapter feel that this meeting was very successful and sufficient ideas were gained in order to do a better job of this next year.

LEHIGH VALLEY

The regular monthly meeting of the Lehigh Valley Section was held on December 1st at the Hotel Bethlehem, Bethlehem, Pa.

W. J. Poehlman, of the A. O. Smith Corp., Milwaukee, Wis., talked on "Spectroscopy as Applied to Welding."

Mr. Poehlman gave a brief review of the origin and history of the spectroscope, and told of its use as a means of rapid qualitative and quantitative analysis of welds. He pointed out that the quality of material is a vital factor in obtaining satisfactory welded products. He discussed control testing equipment used in a modern laboratory along with some typical results obtained in practical applications.

A continuation of a coffee talk by H. O. Hill of the Bethlehem Steel Co., newly elected President of the A.W.S., describing his recent trip to Norway and Sweden, which was limited at the last meeting, was given prior to the technical meeting. G. E. Doan, Section Chairman, presided at the meeting.

LOUISVILLE

Edgar P. Auler, superintendent of welding and pipe fabrication for Taylor Forge and Pipe Works, Chicago, Ill., was the guest speaker at the dinner meeting in the Seelbach Hotel, November 25th.

Mr. Auler spoke on "Controlled Low-Temperature Stress Relieving with the Oxyacetylene Flame" as developed and used for reducing longitudinal welding bead stresses in mild steel penstock piping for hydroelectric plant installations.

The process uses special oxyacetylene torches 6 in. wide, on each side of the weld, and moving at such a rate as to raise the temperature of the metal adjacent to the weld to from 350 to 400°. Water sprays for quick cooling follow a few inches behind the torches.

The talk was illustrated with lantern slides of photographs and charts. A discussion period followed the talk.

The program was closed by the showing of a color movie film showing the uses of oxyacetylene cutting for production work.

MARYLAND

The November meeting of the Maryland Section was held on the 21st in the Engineers' Club of Baltimore. Dean W. B. Kouwenhoven, Dean of Engineering at Johns Hopkins University, presented a coffee talk on "Resuscitation from Electric Shock." Dean Kouwenhoven compared the effects of shock from alternating and direct current, and projected a motion picture in color of experiments which evaluated the effectiveness of several methods of resuscitation.

The technical speaker of the evening was John D. Bert, Welding Engineer at the U. S. Navy Yard, Philadelphia. Mr. Bert posed the question "What Is Good Welding?" and then proceeded to give a clear, precise answer that pointed out the responsibilities of the operator, inspector, welding engineer and designer in the making of a satisfactory weldment.

A membership drive for the Maryland Section directed by M. A. Hansen, Chairman of the Membership Committee, has produced excellent results, 60 new members have been added to the roster. Top honors among those who used blood, sweat and ballpoint pens went to J. F. Gulley and Paul Edmiston.

MICHIANA

Joe Humberstone of Arcrods Corp., Cleveland, Ohio, spoke on the subject "Lime-Ferritic Arc Welding Electrodes" at the November 21st meeting held in the Bendix American Legion Hall, South Bend, Ind. Mr. Humberstone was the "king pin" in the development of the lime-ferritic type of electrodes, and as such, he was in a position to answer the questions asked during the discussion which followed the presentation of his paper. A sports review film "Knockouts" was also shown.

MILWAUKEE

A general discussion on the mechanical and physical properties of nickel, Monel and Inconel was presented by R. M. Wilson, Jr., in a talk entitled, "The Welding of Nickel and High Nickel Alloys," before the Milwaukee Section on Friday evening, November 21st, at the Ambassador Hotel, Milwaukee.

Particular characteristics which relate to welding of nickel and high nickel alloys were discussed as well as problems encountered when joining these materials and when joining dissimilar materials by all common welding, brazing and soldering processes. Mr. Wilson accompanied his talk with slides to emphasize the high points of his discussion.

NEW JERSEY

The regular dinner meeting of the New Jersey Section was held on November 18th at the Hotel Essex House, Newark, N. J. Mr. Everett Chapman, Consulting Engineer of West Chester, Pa., was the speaker at the meeting. His subject was "Fundamentals of Welded Joint Design." Drawing upon his extensive experience as a designing engineer and a pioneer in the production use of flame cutting and welding, Mr. Chapman considered the role of joint design in welded fabrication. An attendance of 95 thoroughly enjoyed Mr. Chapman's presentation of this interesting subject.

NEW YORK

When the program committee received word on the day of their December meeting that the scheduled speaker had been sent to the hospital, they hastily assembled a group of experts to conduct a panel session on the announced subject of "Fabrication of Stainless Steel." The experts included Messrs. Charles Kandel of Craftsweld Equipment Corp. speaking on "Cutting Processes," Robert Metzler of Handy & Harman on "Silver Brazing," F. J. Pilia of The Linde Air Products Co. on "Inert-Gas-Shielded Arc Welding and Oxyacetylene Welding" and E. Vom Steeg of General Electric Co. on "Arc Welding." S. Blickman of S. Blickman, Inc., technical chairman of the session, covered the subject from the fabricator's viewpoint.

The response of the audience indicated that the substitution was well received. More than 30 members of the audience took part in the hour-long question period following the brief talks by the pannel of experts.

Arrangements for the original meeting and the emergency substitution were in charge of E. B. Stolle, of Midwest Piping & Supply Co., Inc. A motion picture on the cutting of stainless steel was supplied by Air Reduction Sales Co. Despite the last minute nature of the arrangements, members who attended felt that it was one of the best meetings of the year

NORTHERN NEW YORK

This Section held its October meeting in Pittsfield, Mass., on October 30th.

R. C. Miller, Jr., of the Thomson Laboratory, General Electric Co., Lynn, Mass., spoke on the subject of "Metallizing." Ralph S. Pelton, Works Laboratory, General Electric Co., Schenectady, N. Y., assisted in the demonstrations featuring the metallizing of copper and low-carbon steel.

The meeting was a dinner meeting and was attended by approximately 40 persons, including 15 members of the Northern New York Section living in Schenectady and two from Hudson, N. Y.

Romance, music, history and good food were featured at the "Ladies Night" meeting held on November 20th at the American Locomotive Club. Following dinner, a March of Time sound film presentation of the "Music of the Americas" and another on the "Music of Romance" were shown. The musical program was arranged by H. S. Swan, Welding Engineer, American Locomotive Co., Schenectady.

L. L. Wyman, G-E Co. Research Laboratory, gave an exceedingly interesting talk covering the history of basic metallurgy. Mr. Wyman's "Metallurgical Calendar" covered the development of gold, silver, copper and special steels with interesting stories explaining how some of the barbaric people achieved the desired metallurgical results by quenching saber blades in the body of a Nubian slave, or treating metal with the ashes derived from bones removed from calves' heads, etc. These examples and others, such as how bells were successfully welded in the 16th century, were compared with today's techniques which resemble the historical processes.

The regular informal roundtable discussion, which is conducted the first Tuesday night of each month by Roger W. Clark, continued on schedule.

OKLAHOMA CITY

The Oklahoma City Section held its December meeting at the Biltmore Hotel on Friday, November 28th. At that time there were 48 members and guests present to listen to the speaker of the evening, LaMotte Grover of the Air Reduction Sales Co., New York. Mr. Grover's talk was very well received and the question-and-answer period at the close of his talk was particularly active.

It was reported that in addressing the group, Mr. Grover steered as clear of technical phrases as possible and thus was able to get his points across very well to the rather mixed type of group which usually attends Section meetings here.

The Section was particularly happy to have with them at this meeting Homer X. White of the Oklahoma State Highway Commission.

As a kind of preface to the speaker of the evening, the Section was able through the kind offices of Howard Simms of Black, Sivalls & Bryson, to secure the services of Mr. Sparagoski, who offered a short program of magic and sleight of hand.

PASCAGOULA

The November dinner meeting was held on the 12th at the Pascagoula Country Club with J. A. Furr as toastmaster. Dr. G. C. Holder, Chief Metallurgist Chemist, Foster Wheeler Corp., presented an illustrated talk on "Welding Distortion and Control of Same." Two movies were also shown as follows: (1) "Intestinal Fortitude" and (2) "Mass Production of Massive Parts."

The December dinner meeting was held on the 3rd at the Pascagoula Country Club with LaMotte Grover as toastmaster. George C. Baumunk, Metal Goods Corp., St. Louis, Mo., presented an interesting talk on Physical and Chemical Characteristics of Stainless Alloys.

Speaker Dr. G. C. Holder, Foster Wheeler Corp. at Pascaggula Section Meeting

PHILADELPHIA

On Thursday evening, November 6th, a meeting under the sponsorship of the Ohio Nut and Bolt Co. was held at the Benjamin Franklin Hotel, Philadelphia.

E. C. Crowther reviewed the history of the development of projection welding nuts and bolts and R. A. Reich presented an excellent talk on the factor affecting the production of these items and the reasons for the types that have become standard in the industry. An extended discussion followed these talks in order to determine the best method of promoting the use of projection welding so that more manufacturers could take advantage of this process.

R. J. Whelan, President of Ohio Nut and Bolt Co., announced they are setting up a laboratory to further development work of various types of projections and J. L. Nichols, District Manager for P. R. Mallory and Co., Inc., offered the use of his company's laboratory facilities for similar work.

The Philadelphia Section also held a Panel Session on the Welding of Aluminum. With W. R. Crawford of ACF-Brill Motor Co., principal speaker, and O. C. Frederick of the General Electric Co., acting as discussion leader, the Section staged quite a lively meeting on the various problems confronted in the welding of aluminum especially as it pertains to the fabrication of transit vehicles.

This was an open forum type meeting and there was quite an exchange of experiences from representatives of such companies as The Budd Co., RCA Manufacturing Co., Heintz Manufacturing Co., Turco Products, Inc. and Mack Manufacturing Co., together with representatives of the various machine and electrode manufacturers.

The regular monthly dinner meeting was held on November 17th in the Auditorium of the Engineers' Club. A. M. Unger, Chief Welding Engineer, Pullman Standard Car Mfg. Co., presented an inspiring talk on The Welding of Railway Equipment.

PITTSBURGH

A Get-Together Dinner Meeting was held on November 19th in the Hotel Webster Hall, Mellon Institute. This meeting was in the form of a Pressure Vessel Symposium, with R. B. Lincoln, Chairman, Director of National Welding Testing Bureau, Pittsburgh Testing Laboratories, Pittsburgh. Subjects and speakers were as follows: "Design and Fabrication of Large Pressure Vessels," by E. W. Forker, Vice-President, Blaw-Knox Division, Blaw-Knox Co.; "Design and Fabrication of Small Pressure Vessels," by Earl E. Johnson, Products Design Engineer, The Scaife Co., Oakmont, Pa., and "Inspection and Test of Boilers and Other Pressure Vessels," by Paul Cassidy, Chief Inspector Pittsburgh Dept., Hartford Steam Boiler Inspection and Insurance Co. There were 140 in attendance. All talks were very well received.

PUGET SOUND

The first meeting of the new season was held on September 10th when Mr. Bristow, Vice-President and General Manager of King Bros. Steel Fabricators, gave a talk on "Steel and Its Abuse." This was a very interesting talk as it was given by a practical man who could describe in ordinary terms, understandable to the average operator, what happens to steel when it is welded. Since this meeting the Section has had considerable discussion urging them to secure more speakers from the operating side of the welding industry.

The October 8th meeting had as its speaker Richard Ellis, Vice-President and District Manager of the Austin Co. in Seattle, who spoke on the subject "The Present Trend in Structural Welding." A lot was learned by all, particularly with reference to the use of H-beams in steel structures.

Elmer E. Gunnette, Northwest District Field Engineer for the American Institute of Steel Construction, also gave a discussion on welding as affected by the Pacific Coast Uniform Building Code recently adopted in this area.

The November 12th meeting presented Mr. Seedorf of the Progressive Welder Co. with his subject, "Portable Spot Welders." Inasmuch as the Section has not had many speakers from the resistance welding industry this was a very educational evening. A film by the Alcoa Co. on spot welding of aluminum was shown.

ROCHESTER

Regular monthly dinner meeting, cafeteria style, was held on Thursday, December 4th, in the Todd Union River Campus, University of Rochester. The technical meeting was held in the Engineering Building, University of Rochester. Speaker was Ira T. Hook, Research Engineer, American Brass Co., who spoke on "Application of Copper Alloy Welding Rods." Slides dealing with welding problems in copper alloys illustrated the talk. A movie on Open Pit Copper Mining in Chile was also shown. This was a sound, Kodachrome picture covering mining, crushing, leaching, electrolytic refining and casting processes employed in obtaining copper from the world's largest known deposit of copper ore.

SAN FRANCISCO

Little did Robert Fulton dream of the problems he was presenting to ambitious twentieth century engineers, when he harnessed the power of steam to move his paddle wheel steam boat.

Steam superheated to 900° F. at 650 psi., more dangerous than dynamite, to be controlled to perform the titanic task of propelling the great dreadnaughts of the seas.

How to accomplish this seemingly impossible task by welding, with positive assurance that failure cannot occur, was presented by Grover A. Hughes, Senior Engineer, San Francisco Naval Shipyard, to the San Francisco Section at their October 27th meeting.

"Operation Crossroads," a sound motion picture, was a second feature. The U. S. Navy's official record of its experiments at Bikini Atoll as to the effect of the atom bomb on Navy craft.

Over 85 members and guests were in attendance.

SOUTH TEXAS

Frank Neal of the General Electric Co., Houston, was master of ceremonies at a True or False Quiz on Welding Fundamentals held on November 7th. Some of the questions used in conducting this program proved to be very controversial, and a lively discussion followed the actual marking of the quiz papers. Questions included pertinent facts on work with oxyacetylene, electric arc welding, electrode classification, etc.

Mr. LaMotte Grover, Welding Engineer of the Air Reduction Sales Co., New York, was the speaker at the December 1st meeting held in The Houston Club. Mr. Grover's subject was "Testing of Metals for Welded Construction." He discussed the development of various tests that have been made by research organizations in an effort to establish procedures for welding complicated structures with a minimum of concentrated stresses. Information obtained from these and other tests is used in setting up design data, and in making recommendations for welding the more commonly used materials, according to Mr. Grover, and steel companies are cooperating in an effort to provide material that is readily weldable while maintaining the desired "toughness."

SYRACUSE

The speaker at the October 15th meeting was Mr. LaMotte Grover, Welding Engineer of the Air Reduction Sales Co., New York. Mr. Grover discussed the use of welding in structural steel work. Among other things Mr. Grover said that the lack of knowledge of welding by design engineers has caused poorly designed structures from the economic standpoint resulting in costs which are higher than they should be.

Lewis C. West acted as Technical Chairman. The local talk was given by former chairman, A. M. D. Cassel, who spoke on the flux injection method of cutting stainless and clad steels. He stressed the need of removing the oxide layer, the critical distance of the flame tip from the metal surface and the need of maintaining a low temperature for 18-8 stainless to prevent carbide precipitation.

A motion picture was shown to illustrate the engineering and welding service offered by Lukenweld, Inc., in all sizes of weldments on a production basis. The meeting was sponsored by the Smith & Caffrey Co., Empire Structural Steel Co. and the Syracuse Engineering Co.

The November 12th meeting was a highlight in the year's program with Dr. Dewitt C. Smith of the Harnischfeger Corp. in Milwaukee. He gave a very clear explanation of the advantages and uses of the common electrodes with their coatings including E6010, E6011, E6012, E6013, E6020 and E6030. His slides and charts clearly illustrated the differences between these and showed which would be best to use for a particular application.

J. T. Hotchkiss, Bentley Weldery in Syracuse, the local chairman, gave an extensive report on the exhibits and lectures at the October Metal Show and National Convention. The meeting was opened by a movie on "Bowling." The

How a NI-ROD build-up saved a 3-month lay-up

From Canada comes the story of how the cast iron main gear of a big power shovel, made in England, had stripped 74 of its 76 teeth.

Getting a new gear meant a delay of 3 to 4 months... and the shovel was urgently needed. So, the owners called the Bowers Machine Company of Canada to repair the present gear.

Welding seemed the only solution. But, cast iron welds were generally considered risky propositions. So, Bowers turned to G. D. Peters and Company, Ltd. for their opinion.

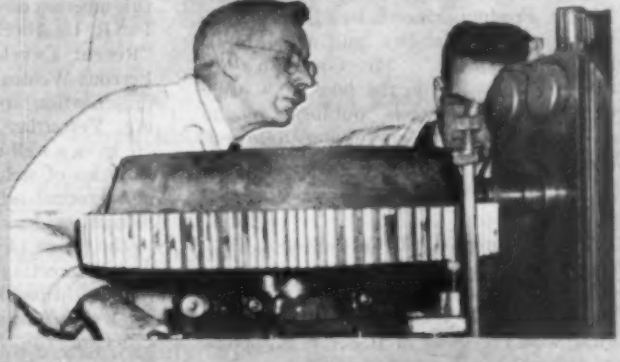
Yes, indeed, Peters' men reported, it was possible to build up this gear. But, it called for careful control... and a high quality Nickel-cored electrode called Ni-Rod.

See below the step-by-step picture story of how this unusual job was done.

1 After degreasing in carbon-tetrachloride, and a thorough cleaning, the damaged teeth were ground down to offer a smooth surface for welding. Where teeth were broken off flush, holes were drilled in the rim and tapped. Studs were then inserted to lend extra support to the new teeth.

2 Before welding, the heavy cast gear was suspended over a temporary oven and heated with an oil torch to 600° F. This eliminated stresses and the possibility of cracking. The welding electrode used was ⅛" Ni-Rod at 95 amperes. After making one pass on one tooth, the gear would be given a quarter turn to assure even distribution of the welding heat.

3 This photo shows finished Ni-Rod "build-ups" on 6 of the teeth. To cut down machining time, tooth-size formers were used to enable the welder to gauge the depth of his deposit. These formers were of brass because Ni-Rod does not fuse with that metal.



4 After the gear had gradually cooled overnight in a low coke fire, the work of milling and machining began. Above illustration shows teeth being milled into Ni-Rod deposits. This work, says Bowers, proved to be easier than expected because the Ni-Rod deposits machined perfectly. Thus, instead of a 3 or 4 month lay-up, the excavator was back on the job in less than 2 weeks.

*Reg. U. S. Pat. Off.

Ni-Rod comes in 3/32" to 3/16" diameters. Order a 5-lb. package and you'll agree it's the solution to any cast iron welding problem calling for strong, crack-free, machinable joints. *Write for free Ni-Rod instruction booklet.*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE
INCO NI-ROD
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GET NI-ROD FROM:

Whitehead Metal Products Company, Inc.
Steel Sales Corp. — Williams and Company
Pacific Metals Company, Ltd. — J. M. Tull Metal & Supply Co.
Eagle Metals Co. — Metal Goods Corporation
Robert W. Bartram, Ltd. — Alloy Metal Sales, Ltd.
Wilkinson Company, Ltd. — Metal & Thermit Corporation
Hollup Corporation — National Cylinder Gas Company

technical chairman was Harry Miller of Carrier Corp. and the sponsor for this meeting was the Prosperity Co.

The December meeting was held on the 10th at the Hotel Syracuse. The meeting featured J. R. Hunter, Welding Metallurgist for Revere Copper & Brass, Inc., who gave an illustrated talk on the fabrication of copper and copper alloy weldments. He showed how, with the use of special fluxes, copper base alloys can be welded automatically with a submerged arc.

An interesting discussion followed Mr. Hunter's talk to the 102 interested men from Central New York.

The meeting was opened by a movie on the arc welding of stainless steel.

Joseph V. Kielb of the Easy Washing Machine Corp., gave an excellent local practical talk showing how a gasoline engine base was changed from a complicated riveted construction to a simple arc-welded design to lower costs and meet production demands. He also showed how a complicated part was changed eliminating several press operations and special dies by using a standard simple stamping brazed to a piece of tubing.

The meeting was closed with refreshments furnished by the Easy Washing Machine Co.

TOLEDO

A joint meeting of the local Sections of the A.W.S. and A.S.M. was held on November 20th at the Maumee River Yacht Club. Dinner preceded the meeting. Speaker at the dinner was Max Cooley, Chief Chemist, Larrowe Div., General Mills, who spoke on Artificial Insemination. Speaker at the technical session was J. A. Grodrian, Chief Metallurgist, Bendix Products, South Bend, Ind., who spoke on "Weldability and the Metallurgy of Welding." Mr. Grodrian's remarks were based on the booklet "Guide to Weldability of Steels" published by the A.W.S. A spirited discussion followed.

TULSA

The first meeting of the 1947–48 season was held on Thursday, September 11th, in the Ivery Room, Mayo Hotel. G. N. Sieger of the S-M-S Corp., Detroit, and First Vice-President of the A.W.S., spoke on two subjects as follows: "Future Responsibility of the AMERICAN WELDING SOCIETY" and "Resistance Welding."

The October meeting was held on the 7th in the Early American Room, Hotel Tulsa. H. W. Cardwell, Jr., of the Cardwell Manufacturing Co., Inc., Wichita, Kan., spoke on the subject "Manufacture and Marketing of Heavy Oil Field Equipment." Mr. Cardwell's talk dealt principally with the manufacturing angle. In conjunction with his talk a Kodachrome film showing field operations of Cardwell drilling equipment was shown.

WASHINGTON

The demonstrations and displays, featured in this year's program of the Washington Section, have already been presented and have proved a success. In each case, the demonstration, which was held in the afternoon, has been followed by a talk on a related subject for the technical session in the evening.

Following a display and demonstration of Heli-arc welding equipment on Oct. 28, 1947, the Section enjoyed an interesting and instructive talk on the subject of "Heli-arc Welding of Lightweight Metals" by H. Thomas Herbst.

The second demonstration was of low-temperature brazing processes and applications. It was given on Nov. 25, 1947, and was followed by a talk by Anthony M. Setapen entitled, "Low-Temperature Silver Brazing Alloys."

Relating the talk of the evening with an afternoon demonstration is proving successful and it appears that this procedure will be followed for many future meetings as it gives the members of the Washington Section an opportunity to see these processes in action. Such an opportunity is not readily available in Washington because there is very little actual industrial development in and about the city. Both of the speakers supplemented the purpose of the duplex program by relating their talks to the demonstrations witnessed.

At the third meeting of the season, the Washington Section of the Welding Society were guests of the Washington Chapter of the American Society for Welding. At this meeting on the evening of Dec. 8, 1947, Dr. R. H. Aborn presented a talk entitled, "Recent Developments in Metallurgy of Ferrous Welding." Dr. Aborn formed his presentation around the theme of "Welding, Yesterday, Today and Tomorrow." He gave a well-rounded outline of the possibilities of welding, its shortcomings, the most recent advances and he mentioned intriguing ideas in speculating with regard to the future of this branch of engineering. At this meeting, the two Society Sections were additionally honored by a short talk by Rear Admiral C. E. Braine, Deputy Chief of the Material Division, U. S. Navy. He briefly described the work of his division with regard to keeping the Navy and its allied industries prepared for immediate reconversion to wartime production schedules. He cited the need for new materials and processes and described steps being taken to dovetail such new elements into the production structure. He concluded with a plea to the engineers present to keep the Navy appraised of new developments and to keep the interests of the nation ahead of selfish competitive desires which might encourage the shelving of new ideas and materials before the Navy had an opportunity to learn of their existence.

WESTERN MASSACHUSETTS

Dinner meeting was held in the Sheraton Hotel on November 19th. E. H. Turnock, Supervisor in Engineering, Westinghouse Electric Corp., presented an interesting address on "Welding Electrodes and A.-C. Welding." A film "Trend to A.-C. Welding" was also shown. Both talk and film were very well received.

WORCESTER

A meeting of the Officers and Directors of the Worcester Section was held on Wednesday, November 5th, at 192 Chandler St. The meeting was opened with the members congratulating James Forand on his winning a Lincoln Award of $150.

Meeting adjourned early as an invitation was extended to visit the Norton Co. plant.

The November 24th dinner meeting was held at the Svea Gille Club, Shrewsbury, Mass. Robert J. Greer, Welding Specialist, Welding Engineering Sales Corp., spoke on the subject "Product Design and Application for Resistance Welding." A film "This Is Resistance Welding" was also shown, as well as a display of resistance-welded samples. There were 65 present at this meeting.

The January meeting will be held on the 26th. The subject will be "Pressure Welding" (Gas).

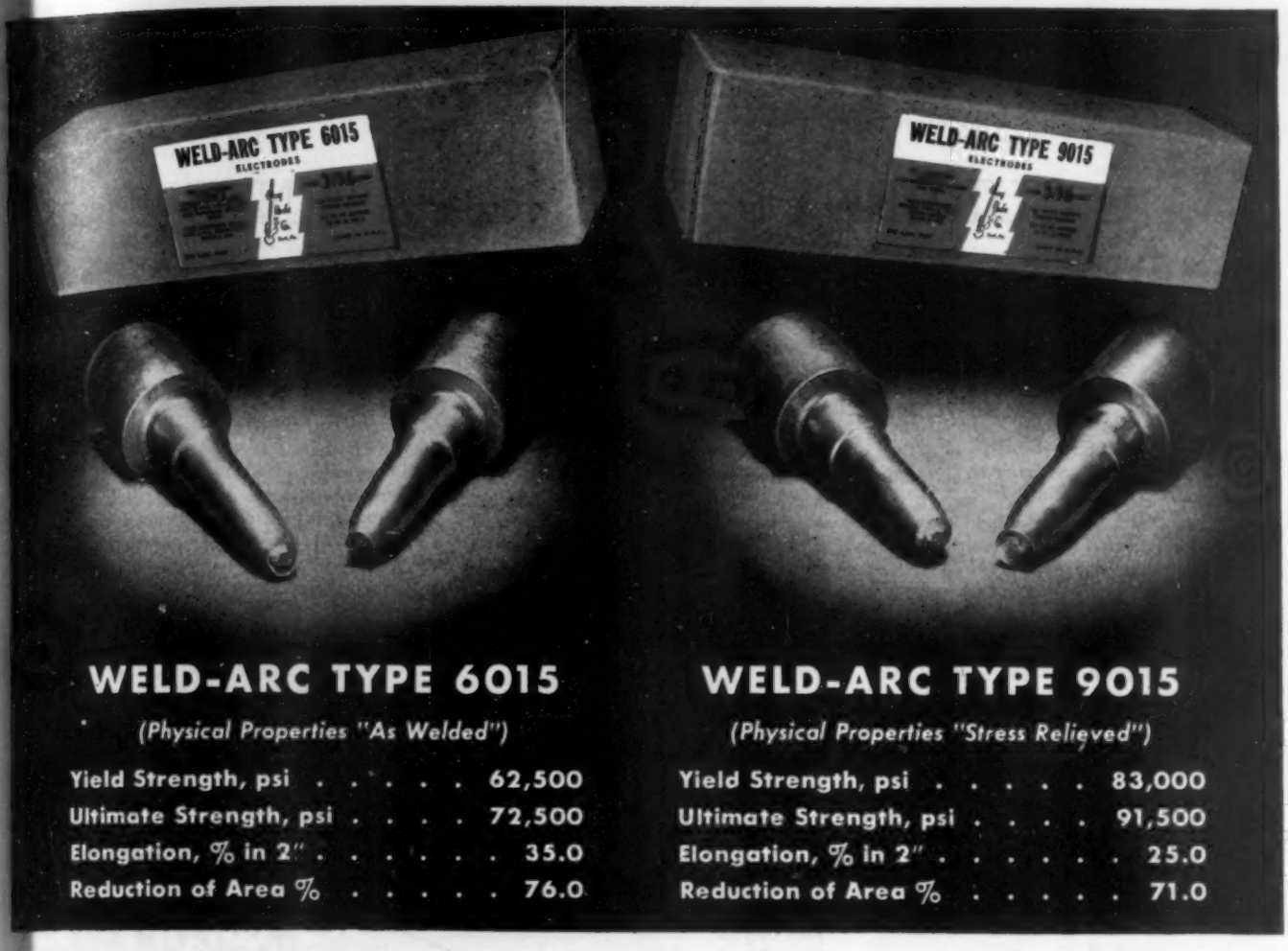
YORK-CENTRAL PA.

"The Welding of Grey Iron Castings" was the subject of the December 3rd meeting held in the Engineering Building, York, Pa. Lew Ames of the Air Reduction Sales Co was the speaker. He supplemented his talk with a generous number of photographic slides taken on actual jobs he engineered and supervised.

CANADIAN

The second meeting of the 1947-48 season of the Montreal Chapter of the Canadian Welding Society was held on Monday, November 28th, in the Carting Room, Berkeley Hotel. Frank E. Kessler, Field Engineer, Welding Equipment & Supply Co., Detroit, Mich., spoke on "Tool and Die Welding." Two sound films entitled "Let's Get the Low-Down" and "Let's Do It Right" were shown.

The Toronto Chapter held its December meeting on the 1st at Malloneys Art Gallery. R. D. Thomas, Jr., Vice-President, Arcos Corp., Philadelphia, Pa., spoke on "The Testing of Stainless Steel Electrodes."



WELD-ARC TYPE 6015

(Physical Properties "As Welded")

Yield Strength, psi	62,500
Ultimate Strength, psi	72,500
Elongation, % in 2"	35.0
Reduction of Area %	76.0

WELD-ARC TYPE 9015

(Physical Properties "Stress Relieved")

Yield Strength, psi	83,000
Ultimate Strength, psi	91,500
Elongation, % in 2"	25.0
Reduction of Area %	71.0

What is a low hydrogen electrode?

The low hydrogen electrode represents the latest development in arc welding electrodes and is so named because the weld deposit has an exceptionally low hydrogen content. The low hydrogen weld deposit is produced through careful selection of coating ingredients and a carefully controlled high temperature baking cycle.

This type of electrode greatly widens the field of arc welding—making it possible to satisfactorily weld high carbon and low alloy steels, high sulphur-free machining steels, cold rolled steels and enamelling steels.

In addition to Weld-Arc Type 6015 and Weld-Arc Type 9015, the Alloy Rods Company also manufacture the low hydrogen electrode in 3% and 5% nickel steel grades for low temperature impact applications.

All low hydrogen electrodes manufactured by the Alloy Rods Company are packed in moisture proof packages which assure maximum weldability, freedom from porosity and highest physical properties.

Request samples from your local Alloy Rods Company distributor or write direct to factory, York, Penna.

Look for the ***FLAMING-ARC*** *trademark*

Alloy Rods Co.

York, Pa.

ABSTRACTS OF CURRENT WELDING PATENTS

Prepared by V. L. Oldham

Printed Copies of patents may be obtained for 25¢ from the Commissioner of Patents, Washington 10, D. C.

2,429,825—WELDING ELECTRODE HOLDER—Harold R. Kruitbosch, inventor, Bridgeport, Conn., assignor to the Electroloy Co., Inc. (5 Claims)

This patented electrode holder has a cooling fluid path formed therein and it also has a plunger provided in the electrode holder, which plunger can be moved axially of the holder for ejecting an electrode contained therein.

2,430,055—BLANKETED ELECTRIC ARC METHOD OF MAKING INTERMITTENT WELDS—Harry E. Kennedy, inventor, Berkeley, Calif., assignor to The Linde Air Products Co. (1 Claim)

Kennedy's patented welding method includes the steps of immersing a metal electrode into a blanket of welding material particles on a workpiece, and supplying an alternating electric current across the electrode and workpiece to fuse the end of the electrode and form a gap of increasing length. Ultimately the voltage will no longer bridge the gap so that an intermittent weld-forming method is provided.

2,430,237—WELD ANALYZER—Frank L. Moncher, inventor, Detroit, Mich., assignor to General Motors Corp. (17 Claims)

The patented welding analyzer includes means for translating operating factors into proportional electrical voltages and recording means are associated with the translating means so that the voltages can be viewed or studied. Switching means also are provided so that the voltages of the different factors may be alternately applied to the recording means at rapidly changing instants.

2,430,260—PERMISSIVE WELDING DEVICE—Winfield J. Trott, inventor, Detroit, Mich., assignor to General Motors Corp. (7 Claims)

The welding device relates to apparatus for welding a mechanically weak member to a larger member, and it has clutch means for gripping the relatively weak member and other means for supporting the clutch member and urging such weak member toward the larger member. The clutch means are adapted to slip on the weak member as such member is pressed against the large member and retained against same throughout the fusion and hardening periods of the weld.

2,430,266—BACKING-UP ELEMENT FOR WELDING—Robert F. Zimmerman, inventor, Cincinnati, Ohio, assignor to Lathrop-Hoge Construction Co. (5 Claims)

Zimmerman's backing-up element comprises a linear structure formed of discrete members strung on a flexible support in abutting relation. The backing-up element also has an element that can be lodged in a groove between the pieces to be welded and which also is detachably engaged with the linear structure of the backing-up element.

2,430,376—ELECTRODE HOLDER—Frank G. Van Dyke, inventor, Detroit, Mich., assignor to Bordon Mfg. Co., Inc. (8 Claims)

This patented electrode holder includes a pair of gripping members that are normally spring held in close relation and which have a groove between opposed faces for reception of an electrode. The gripping members have engagement portions thereof that are pivotally associated with the remainder of the holder and which upon relative swinging movement are adapted to engage with the electrode and move same into register with the groove formed between the gripping members.

2,430,419—WELDING ROD—Walter W. Edens, inventor, Wauwatosa, Wis. (7 Claims)

Edens' patented rod is formed from aluminum bronze and has a substantial amount of nickel therein so as to produce a high yield and ultimate strengths without sacrifice of ductility.

2,430,435—PREWELDING CLEANING OF ALUMINUM—Lyman B. Sperry, inventor, Detroit, Mich., assignor to Chrysler Corp. (5 Claims)

The cleaning method comprises the step of removing the aluminum oxide from surface portions of aluminum sheets by treating them with a water solution of oxalic acid and sodium nitrate. The cleaned metal surfaces are dried and thereafter overlapped surface portions of such sheet may be spot welded with reduced sputtering occurring there between.

2,430,511—MIXING ARRANGEMENT FOR TORCHES—Howard G. Hughey, inventor, Fanwood, N. J., assignor to Air Reduction Co. (2 Claims)

The novel torch of this patent includes a body having oxygen and fuel gas passages formed therein with converging gas passages formed in its tip. The oxygen and fuel gas passages of the body have a by-pass connected thereto whereby both oxygen and fuel gas can be flowed d... either passage and a second by-pa... provided adjacent the tip, and a manu... operable valve controls the second by-p... so that mixed gases flowing down one p... age can be caused to flow through t... converging gas passages in the torch ... to produce flame jets that impinge on e... other.

2,430,536—WELDING ELECTRODE HOLD... —Kenneth L. Smith, inventor, Mo... terey Park, Calif. (5 Claims)

Smith's patented holder includes a h... low insulating handle that has a hollo... insulating holder extending therefro... The holder has substantially transverse ... extending holes formed therein and a ... elongated conductor bar extends into t... holder and also is provided with a su... stantially transversely directed ho... therein. The electrode extends throu... the holes in the hollow insulating hold... and bar and a spring biases the conduct... bar outwardly of the electrode holder ... retain the electrode tightly in position.

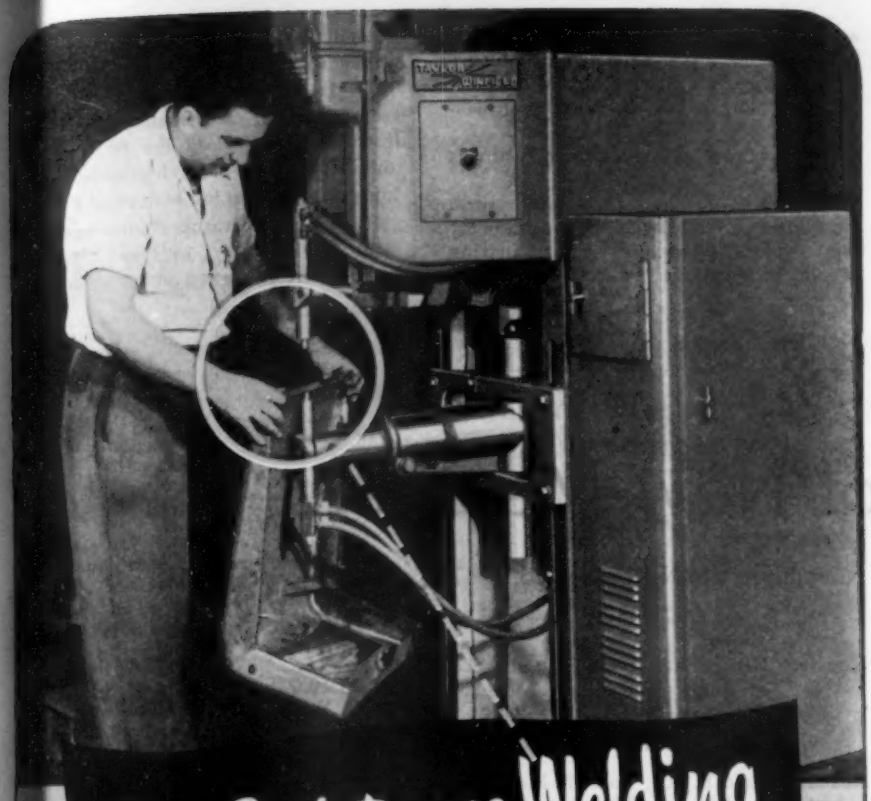
2,430,684—PORTABLE WELDING GUN—Andrew J. Palese, inventor, Wilmington, Del. (6 Claims)

This patent relates to a chuck for hold... ing a headed fastener pin and it is adapte... to be attached to a portable welding gu... The chuck includes a hollow body which ... adapted to be secured to the outer e... portion of a reciprocable plunger rod of ... portable welding gun. A flexible conduc... tor for conducting welding current fro... the plunger rod to the contact head is po... sitioned within the tubular member ... cured to a contact therein and is adapte... to contact the outer end of the plunger ro... in one position of movement of the same.

2,430,701—WELDING ELECTRODE—Arthur A. Bernard, inventor, Chicago, Ill., assignor to National Cylinder Gas Co. (26 Claims)

The patented welding electrode particularly relates to forming an arc enclosed by an inverted crucible and the electrode includes a metal core which has a plurality of longitudinally extending ribs. At least one conductor is spirally wound on the core and a sheath of flux material is positioned in the grooves and overlies the ribs but leaves the spiral conductor exposed at the periphery of the electrode.

2,430,787—FLASH WELDER CONSTRUCTION—Melvin M. Seeloff, inventor, Warren, Ohio, assignor to The Taylor-Winfield Corp. (26 Claims)



Put Resistance Welding Costs on the spot

...use Ampco-Weld resistance welding electrodes in modern equipment...increase the number of welds made, substantially reduce your costs

Sturdy! Versatile! These are the words that best describe this spot and projection welder, because it provides long life operation with a minimum of maintenance.

The same words apply to the Ampco-Weld electrodes used in this machine. Here's why:

Terne plate and galvanized stock, as you know, normally require the use of R.W.M.A. Class I electrodes. Yet, these two items are easily handled by Ampcoloy 97, a Class II alloy that combines the conductivity of Class I with the hardness of Class II. The ability of Ampcoloy 97 to do such jobs gives you clean welding and longer electrode life.

It pays to use Ampco-Weld electrodes in your resistance welding set-up. Get a supply today and see for yourself. The Ampco-Weld line is complete—it includes standard and special holders. All products meet R. W. M. A. specifications. Call your nearest Ampco office. Write for our latest fact-filled bulletin — it is just off the press.

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Ampco Metal, Inc.

Department WJ-1 Milwaukee 4, Wis.

AMPCO TRADE MARK

Field offices in principal cities

RW-9C

This patented machine is for electric resistance flash-butt welding operations and it includes a pair of spaced frame members which have a fixed platen rigidly secured therebetween. A header member also is rigidly interconnected between the frame members. The frame members also carries a side rail for slidable longitudinal movement and a movable platen is supported on the side rails. A cylinder and piston are secured between the movable platen and the header member while guide means are associated with the movable platen to control its longitudinal movement.

2,430,989—Mechanism for Controlling Welding Current—Raymond J. Miller, inventor, Detroit, Mich. (5 Claims)

Miller's patent relates to an electrode holder which has a handle, a casing clamped to the handle and oppositely disposed longitudinally spaced levers pivotally mounted in the casing. The levers are connected so that movement of one lever is transmitted to the other to induce similar movement therein. A control member is positioned within the casing and connects to one of the levers for limiting its movement.

SPIN DISKS IN "WHIRL PIT" TO TEST STEEL AND WELDS

Science is using "spinning disks" as a method of testing welds and steels in a research program now going on at Massachusetts Institute of Technology sponsored by the Welding Research Council of the Engineering Foundation, officials of the Foundation announced recently. This is one of a number of projects for basic research on engineering problems to which the Engineering Foundation annually allocates funds.

In an armor-plated "whirl pit" 40 in. in diameter and 9 ft. deep, circular steel plates are rotated at high speeds until they burst. "This is one of the most promising of the new testing methods to provide biaxial stress all the way to fracture," W. Spraragen, Director of the Welding Research Council, stated. "It makes it possible to test thicker welded and unwelded plates than is possible by other methods."

"One of the most valuable uses projected for the rotating disk method will be to test materials and welds at extremes of temperature, and the results should be particularly useful to bridge engineers, shipbuilders, the U. S. Army and Navy and those who use steel at extremely low winter temperatures," he said.

The project is under the direction of Dr. C. W. MacGregor, professor of applied mechanics at M.I.T. All tests so far have been pilot tests with the purpose of perfecting the method and equipment. The disks, which can be tested to a thickness of 8 in., are suspended on a flexible steel drive shaft and rotated in a 30-in. vacuum at speeds up to 35,000 rpm. The vacuum prevents the generating of heat in the plates as they are rotated and makes it possible, by admitting air, to stop the whirling at any given moment.

The whirl pit itself is made of three heavy pieces of class B armor plate, and is lined with lead pigs to preserve the disks for observation and measurement after fracture. To date, the disks tested have all been 26 in. in diameter but of different thicknesses. For welding tests, a small central disk is welded within the outer disk.

As the disks whirl at high speed, the material actually flows from the center toward the edges and thickens the disks at the perimeter. It is expected that future tests will provide interesting information on plastic flow and on distribution of plastic strains.

The program outlined for the future is as follows:

1. Study of plastic flow and strain distributions on disks 26 in. in diameter rotated to partial yielding and to bursting at room temperature; on welded disks, as-welded and stress relieved; and on unwelded disks annealed and as hot rolled.

2. Development of wire strain gage techniques for measurement of brittle fracture conditions at low temperatures, and construction of a refrigeration system for testing disks at low temperature.

3. Low temperature studies on disks of same thickness ($^3/_4$ to 1 in.) unwelded, welded, stress-relieved and as-welded.

List of New Members

November 1 to November 30, 1947

CHICAGO

Elkin, Louis D. (B), 3815 N. Kenmore Ave., Chicago 13, Ill.
McKinney, Peter T. (B), The Linde Air Products Co., 230 No. Michigan Ave., Chicago 1, Ill.
Taylor, Charles H. (C), 222 So. Connecticut St., Hobart, Ind.

CINCINNATI

Dusterberg, Burton J. (C), 6116 Tulane Rd., Cincinnati 13, Ohio
Holley, C. F. (C), Box 183, Cincinnati 15, Ohio.
Kunz, Warren (C), Turrill, Inc., 1035 Woodrow St., Cincinnati 4, Ohio.

CLEVELAND

Amstutz, E. D. (C), 174 Baird Ave., Wadsworth, Ohio.
Bell, Elmer T. (C), 567 Columbus Rd., Bedford, Ohio.
Blewett, Albert (B), 26 Midland Rd., Mentor, Ohio.
Gosnell, Everett C. (B), Colonial Iron Wks. Co., 17643 St. Clair Ave., Cleveland, Ohio.
Hamilton, William L. (C), 20310 Chickasaw Ave., Cleveland 17, Ohio.
Koty, Albert A. (C), Midland Steel Prods., Madison Ave., Cleveland 1, Ohio.
Lehr, Henry (B), Lehr Iron & Steel, Inc., 655 W. Wilbeth Rd., Akron 14, Ohio.
Maurath, George A., Jr. (C), 11430 Cedar Rd., Cleveland, Ohio.
Moore, Raymond M. (C), 20417 Chickasaw Ave., Euclid 19, Ohio.
Pall, Raymond M. (C), 24318 Chardon Rd., Euclid 17, Ohio.
Pember, Harold (C), 144 S. Abbe Rd., Elyria, Ohio.
Perry, Wm. S. (C), The Akron Welding & Spring Co., 940 S. High St., Akron 11, Ohio.
Peters, E. Donald (C), Colonial Iron Wks. Co., 17643 St. Clair Ave., Cleveland, Ohio.
Seivert, George W. (C), 2131 Bunts Rd., Lakewood 7, Ohio.
Welch, Jerold L. (C), 803 Lincoln Blvd., Bedford, Ohio.
Zagore, Frank J. (C), 18024 Gillgrove Rd. N. E., Cleveland, Ohio

COLORADO

Card, D. C. (B), Box 117, Denver 1, Colo.
Koester, Henry (C), 4250 Fillmore St., Denver 16, Colo.

COLUMBUS

Roach, Donald B. (C), Battelle Memorial Inst., Rm. 2106, 505 King Ave., Columbus, Ohio.
Spangler, Marshall (C), Battelle Memorial Inst., Rm. 2104, 505 King Ave., Columbus, Ohio.
Wheeler, Lawrence P. (C), 2458 Renwood Pl. Columbus, Ohio.

DAYTON

Dorsten, Adolph N. (C), National Cash Register Co., Dayton, Ohio.
Schweibold, E. Carl (C), 214 Watervliet Ave., Dayton 10, Ohio.

DETROIT

Althouse, Andrew D. (B), 467 West Hancock, Detroit 1, Mich.
Bender Carl (B), Composite Forgings, Inc., 2300 W. Jefferson Ave., Detroit 16, Mich.
Cameron, J. Russell (B), Dow Chemical Co., 189 Bldg., Midland, Mich.
Cheney, Nelson (B), 516 Sycamore, Wyandotte, Mich.
Guse, William (B), Composite Forgings, Inc., 2300 W. Jefferson Ave., Detroit, 16, Mich.
Hunt, Wayne L. (B), 1322 Jefferson Ave., Midland, Mich.
Johnston, Lloyd E. (B), 706 W. Indian St., Midland, Mich.
Johnston, Willis T. (C), 2714 Walnut St., Midland, Mich.
Kirn, Albert (C), Composite Forgings, Inc., 2300 W. Jefferson Ave., Detroit 16, Mich.
Ladd, Raymond J. (B), Dow Chemical Co., Bldg. 1, Door A, Midland, Mich.
Le Beau, Edward (C), 10056 Somerset, Detroit 24, Mich.
Neumann, Joseph E. (B), 3450 Shattuck Rd., Saginaw, Mich.
Podolak, Henry (C), Composite Forgings, Inc., 2300 W. Jefferson Ave., Detroit 16, Mich.
Rouse, Ewell (C), Composite Forgings, Inc., 2300 W. Jefferson Ave., Detorit 16, Mich.
Thomas, Morris D. (C), 1726 Davison Rd., Flint 6, Mich.
Wagner, Joseph A. (C), Composite Forgings, Inc., 2300 W. Jefferson Ave., Detroit 16, Mich.
Wech, William (C), Composite Forgings, Inc., 2300 W. Jefferson Ave., Detroit 16, Mich.

INDIANA

Lewis, David S. (C), 3343 Central Ave., Indianapolis, Ind.

KANSAS CITY

Frick, J. (C), 3713 Ruby Ave., Kansas City, Kan.
Stewart, A. B. (C), 3939 Springfield Ave., Kansas City, Kan.

LONG BEACH

Silk, Frederic T. (C), 623 W. Tichenor St., Compton, Calif.

LOS ANGELES

Lacke, Francis J. (C), District Steel & Equipment Co., 4536 District Blvd., Los Angeles 11, Calif.
O'Connor, David P. (C), 3222 Sheffield Ave., Los Angeles 32, Calif.
Orr, Charles I. (B), 6840 Newell St., Huntington Park, Calif.
Van Rensselaer, Joseph R. (C), District Steel & Equipment Co., 4536 District Blvd., Los Angeles 11, Calif.

LOUISVILLE

Buckman, Thomas O. (C), Shuler Axle Co., 2901 So. 2nd St., Louisville, Ky.
Clark, Charles L. (C), 4036 Henderson Ave., Louisville, Ky.
Kessler, William A. (C), 2004 7th St. Rd., Louisville, Ky.

MARYLAND

Arnew, H. M. (C), Jack's Welding Service, 7302 Holabird Ave., Baltimore 22, Md.
Blucker, Amos A. (C), Blucker & Mills, First St., Laurel, Md.
Boughan, Fred B. (C), The Fingles Co., 2256 Reisterstown Rd., Baltimore 17, Md.
Bridgers, John (C), North Point Rd., R. F. D. 10, Sparrows Point 19, Md.
Brockman, J. Lawrence (C), Baltimore Steel Co., 1400 Eastern Ave., Baltimore 31, Md.

Clements, Raymond S., Jr. (C), 6725 Boston Ave., Baltimore 22, Md.
Courtney, James A. (C), 407 Park Ave., Baltimore 1, Md.
Dietrick, John F. (C), Baltimore Steel Co., 1400 Eastern Ave., Baltimore 31, Md.
Dodge, Keith A. (C), The Baltimore Ocean Transpt. Co., 4006 East Monument St., Baltimore 5, Md.
Elliott, Gilbert F. (C), 12 Talbott St., Brooklyn, Baltimore 25, Md.
Frazier, C. P. (C), 1700 East Fayette St., Baltimore, Md.
Fromm, O. M. (C), Bethlehem Steel Co., E. R. S., Sparrows Point 19, Md.
Henderson, F. X. (C), 10 Randall St., West Annapolis, Md.
Johnson, Charles William (C), 97-C Stemmers Run Rd., Baltimore 21, Md.
Jones, B. Francis (C), 407 N. Kenwood Ave., Baltimore 24, Md.
Kopka, Ernest (C), 43 Murdock Rd., Baltimore 22, Md.
Lessner, E. D. (C), Cathell Bros. & Co., Fort Ave. & Lawrence St., Baltimore, Md.
Light, Virgil A. (C), L & S Welding Co., 2401 Homewood Ave., Baltimore 18, Md.
McCormick, Charles M. (C), 7 N Culver St., Baltimore, Md.
Ott, Walter Leroy (C), 603 Dorsey Ave., Baltimore 21, Md.
Russell, Howard V. (C), Baltimore Steel Co., 1400 Eastern Ave., Baltimore 31, Md.
Shelley, Franklin C. (C), Heat & Power Corp., 428 E. Saratoga St., Baltimore 2, Md.
Slisky, John Henry (C), 3918 Brooklyn Ave., Baltimore 25, Md.
Trader, Allison C. (C,) Arnold, P. O., Reuell's Station, Md.
Tussing, John A. (C), Baltimore Steel Co., 1400 Eastern Ave., Baltimore 31, Md.
Wallace, Paul M. (C), Glen Rock, Pa.
Wingert, Byron E. (C), 851 Mulberry Ave., Hagerstown, Md.
Wingert, Donald E. (C), 14 Seabright Ave., Dunalk, Baltimore 22, Md.
Youngren, Carl P. (C), Fairfax Rd., R. F. D. 1, Annapolis, Md.
Zink, A. R. (C), Western Welding Co., 110 N. Calverton Rd., Baltimore 23, Md.
Zink, John H., Jr. (C), Heat & Power Corp., 428 E. Saratoga St., Baltimore 2, Md.

MILWAUKEE

Klaus, Joseph J. (C), 1003 W. Oklahoma Ave., Milwaukee, Wis.
Leupold, Glenn W. (C), 2953 No. 37th St., Milwaukee, Wis.
Worden, Stewart W. (B), Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

NEW JERSEY

Kihn, William W. (C), Blue Hill Rd., R. D. 2, Morristown, N. J.

NEW YORK

Cobb, Mortimer (B), Welding Engrg. Sales Corp., 110 E. 42nd St., New York, N. Y.
Marden, Jonathan (B), 305 Decatur Ave., Brooklyn 29, N. Y.
Moody, Norman F. (B), Air Reduction Sales Co., 60 E. 42nd St., New York 17, N. Y.
Shaw, Perrin F., Jr. (B), 279 Prospect St., East Orange, N. J.
Wolcott, John L. (C), Lincoln Electric Co., 330 W. 42nd St., New York, N. Y.
Zwerling, Seymour J. (B), Triangle Sheet Metal Wks., Inc., 115 New Hyde Park Rd., New Hyde Park, L. I. N. Y.

NORTHWEST

Gnauck, Felix G. (B), Minneapolis Tank & Mfg. Co., 1201 Winter St., N. E., Minneapolis 13, Minn.
Maynard, Marcus (C), 818 Wayzata Blvd., Minneapolis 3, Minn.
Smith, E. Wesley (B), General Welding & Machine Co., Inc., 510 1/2 5th Ave., So., Minneapolis 15, Minn.
Zirbes, Arnold M. (B), 3113 Edgewood Ave., St. Louis Park, Minn.

NORTHWESTERN PA.

Naschold, Eric T. (C), 122 Sanford Place, Erie, Pa.

OKLAHOMA CITY

Barnes, Jesse R. (C), 1128 N. W. 34th St., Oklahoma City, Okla.
Brown, R. C. (C), Box 5068, Oklahoma City, Okla.
Bunch, James F. (D), 410 Hester St., Stillwater, Okla.
Ward, E. W. (C), 1121 N. W. 39th St., Oklahoma City 6, Okla.

PEORIA

Bogott, F. Wesley (B), 110-112 3rd Ave., Sterling, Ill.

PHILADELPHIA

Falkenback, John J. (B), Link Belt Co., 2045 West Hunting Park Ave., Philadelphia 40, Pa.
Fleming, Edward A. (C), 1010 Montgomery Ave., Fox Chase Manor, Pa.
Griesel, Edw. G., Sr. (B), Link Belt Co., 2045 West Hunting Park Ave., Philadelphia 40, Pa.
Newkirk, E. H., Jr. (C), 4512 Springfield Ave., Philadelphia 43, Pa.
Wilson, George R. (B), 103 Merion Ave., Narberth, Pa.

PUGET SOUND

McCormick, James (C), 825 4th Ave., No., Renton, Wash.

ROCHESTER

McGrath, Harry A., Jr. (C), 1786 St. Paul St., Rochester, N. Y.
Shanowsky, Walter, (C), 27 Appleton St., Rochester 11, N. Y.

SAN FRANCISCO

Schwarz, A. C. (B), 4023 Bayview Ave., San Mateo, Calif.

SOUTH TEXAS

Malone, Grady H. (C), 3520 Cleveland St., Dallas, Tex.

SYRACUSE

Cagwin, Douglas P. (C), Empire Structural Steel Fabricators, Inc., 1407 Erie Blvd., E., Syracuse, N. Y.
Kisscock, William G. (B), Box 143, Ithaca, N. Y.
Lathrop, George, (C), Sherburne, N. Y.
Mitchell, Norman B. (C), Bldg. 843, Apt. 7, Syracuse Air Base, Syracuse, N. Y.
Staudenmayer, Joseph (C), 207 Roycraft Rd., East Syracuse, N. Y

TOLEDO

Snell, S. W. (C), Odland Iron Wks., Inc., 1202 West Bancroft St., Toledo 6, Ohio.

TULSA

Childress, F. G. (B), Tulsa Testing Lab., 609 So. Peroia, Tulsa, Okla.
Danuser, W. W. (B), 1215 So. Lewis Pl., Tulsa, Okla.
McKee, P. W. (C), Murdock Tank & Mfg. Co., Box 327, W. Tulsa, Okla.
Murdock, F. L. (B), Murdock Tank & Mfg. Co., Box 327, W. Tulsa, Okla.
Wood, D. W. (C), 429 So. 55th W. Ave., Tulsa, Okla.
Woodard, K. A. (C), Murdock Tank & Mfg. Co., Box 327, W. Tulsa, Okla.

WASHINGTON

Heflin, Curtis Augustus (B), P. O. Box 5087, Washington, D. C.
Riley, Calvin Wade (B), 316 34th St., S. E., Apt. 1, Washington 19, D. C.
Souder, Ralph W. (B), R. 4812 Rhode Island Ave., Hyattsville, Md.

WICHITA

Carpenter, Ben (B), Davis Mfg., Inc., 1512 McLean Blvd., Wichita, Kan.
Carroll, I. I. (C), General Welding Co., Inc., 3000 S. Lawrence Rd., R. F. D. 6, Wichita, Kan.
Green, Murl A. (C), Northwest Oxy-Acetylene Dist. Co., 3001 N. Broadway, Wichita, Kan.
Hogue, H. C. (C), The Linde Air Products, Co., 540 E. 17th St., Wichita, Kan.

NOT IN SECTIONS

Barrington, Greig (C), Public Work Dept., Kaitaw, Wairoa, New Zealand.
Davies, John Roland (C), 103 Dryburgh Ave., Rutherglen, Lanarks, Scotland.
Kirchner, Charles H. (C), Engrg. Dept., Fidelity & Casualty Co. of N. Y., 1118 Mutual Bldg., Richmond 9, Va.
Syren, Carl Gustaf (C), Nordiska Armaturfabrikerna, Linkoping, Sweden.
Willson, Kenneth I. (C), 407 Andries St., Pretoria, Union of South Africa.

Members Reclassified

During Month of November

CHICAGO

Bratkovich, Nick (C to B), 5619 S. Natoma Ave., Chicago 38, Ill.

CINCINNATI

Boyd, Richard M. (C to B), Harris Calorific Sales Co., 342 Crescent Ave., Box 183, Lockland 15, Ohio.

CLEVELAND

Lohmeyer, W. J. (C to B), Colonial Iron Wks. Co., 17643 St. Clair Ave., Cleveland, Ohio.
Peters, Julius H. (C to B), The Colonial Iron Wks. Co., 17643 St. Clair Ave., Cleveland, Ohio.

Rose, Otto (C to B), 892 Ravine Dr., Cleveland 12, Ohio.

Stern, Allan P. (C to B). Colonial Iron Wks., Co., 17643 St. Clair Ave., Cleveland 10, Ohio.

LONG BEACH

Preston, Clyde W., Jr. (C to B), 1611 Santa Fe Ave., Long Beach, Calif.

NEW JERSEY

Crowe, J. J. (B to E), Air Reduction Sa... Co., Murray Hill, N. J.

BABCOCK & WILCOX TO BUILD HIGH-PRESSURE TEST VESSEL FOR U. S. NAVY'S UNDERWATER SOUND REFERENCE LABORATORY

A high-pressure test vessel will be built by The Babcock & Wilcox Company for the U. S. Navy's Underwater Sound Reference Laboratory, Orlando, Fla., officials of the company announced recently. This unit is similar to the one now being completed by the company for the Naval Ordnance Laboratory at White Oak, Md., but is designed specifically for Sonar measurements.

The vessel, which has an inside diameter of 100 in. and an over-all straight length of 25 ft. 8 in., will have a 1000-lb. working pressure. It will be fabricated of 4-in. steel having an ultimate tensile strength of 70,000 psi. The vessel will weigh approximately 77 tons.

Designed with two quick-opening nozzles for the introduction of test equipment, the unit will be used to test operation of instruments and fittings under actual conditions of pressure and temperature.

CONVERSION CHART OFFERED FOR X-RAY DIFFRACTION

A new conversion chart for X-ray diffractionists, prepared by the Kodak Research Laboratories, permits rapid calculation of exposures with films of varying characteristics of speed, contrast and graininess.

Where a basic exposure for diffraction has been determined using a given film, the chart provides conversion factors by which exposure for any of five types of film may be computed easily. These factors have been determined at the extremely low photographic densities commonly used for diffraction and are presented for three common target materials: chromium, copper and molybdenum.

The chart also supplies factors which indicate the increase in relative film speed obtained by 8 min. development in comparison with normal development of five minutes. This permits decreasing exposure time by as much as 15%, depending upon the particular film. Since some exposures for diffraction require several hours, such savings of time are important.

The chart is available free upon request from the X-ray Division, Eastman Kodak, Rochester 4, N. Y.

NEW NITROGEN GENERATOR

Gas Atmospheres, Inc., announces development of a new low-cost nitrogen generator known as the "Hi-Nitrogen Generator" for use in the metallurgical, chemical, food packaging, refining, processing and storage industries. The self-contained Hi-Nitrogen Generator is a combustion method unit for producing nitrogen at a cost of a few cents per 1000 cu. ft. of dry gas. The equipment operates on a mixture of air and natural gas or any manufactured gas such as butane, propane, water gas or coke oven gas. An illustrated brochure is available on request from Gas Atmospheres, Inc., 20011 West Lake Rd., Cleveland 16, Ohio.

A.S.A. APPOINTS VICE-ADMIRAL HUSSEY AS ADMINISTRATIVE HEAD

Vice-Admiral George F. Hussey, Jr., USN (Ret.), wartime Chief of the Navy's Bureau of Ordnance, today joined the staff of the American Standards Association and on January 1 will assume the duties as administrative head of that organization. In this capacity Admiral Hussey will continue to serve the nation by directing the cooperative efforts of industry, consumers and government in the vital problem of standardization. Cyril Ainsworth, who for a number of years has been in charge of the technical activities of the A.S.A., will serve with Vice-Admiral Hussey as director of operations of the A.S.A. staff.

Admiral Hussey started his outstanding Navy career in 1912 with an appointm... to the U. S. Naval Academy, and h... served in many capacities requiring t... highest order of skill and ability. Speci... izing in ballistics, Admiral Hussey w... vanced in grade and responsibility to t... position of Chief of Bureau of Ordnan... Navy Department, Washington, D. C. For his service in this capacity he w... awarded the Distinguished Service Me... with the citation:

"For exceptionally meritorious servi... to the Government of the United Stat... as Director of the Production Divisi... Bureau of Ordnance, from 16 June 19... to 3 September 1943. Assistant Chief ... the Bureau of Ordnance from 4 Septemb... 1943 to 10 December 1943, and as Chi... of that Bureau from 10 December 1943 ... 31 August 1945. Through the exercise ... extraordinary foresight, administrativ... ability and forceful leadership, he directe... the design, production and supply of weap... ons, many of the new and revolutionar... types, for the Operating Navy. His ... conspicuous success in the performance ... his duty was a direct contribution to th... prosecution of the war."

In accepting the appointment, Admir... Hussey will take over the tremendous ... increased administrative responsibilitie... from Dr. P. G. Agnew, under whose ca... able direction the A.S.A. has progress... to its present high level. Dr. Agnew, on... of the world's foremost authorities o... standardization, will continue his servi... to A.S.A as Consultant.

The American Standards Associatio... faced with an unprecedented demand fo... service to industry, consumer and gover... ment expects to increase its activities du... ing the next year to approximately thre... times that of the largest year before th... war. At the present time there are ove... 366 projects being carried on under A.S.A... procedures with more pending. Proj... ects such as the standardization of wom... en's dress sizes, business methods, and ... symbols for use in work on supersoni... projectiles and airplanes are indicative o... the wide range of subjects covered in th... many requests for service.